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MANUAL OF ASTRONOMY,

AND THE

USE OF THE GLOBES,

FOR

SCHOOLS AND ACADEMIES.

BY

HENRY KIDDLE,

PRINCIPAL OF PUBLIC SCHOOL NO. 2, CITY OF NEW YORK.

NEW YORK:
IVISON & PHINNEY, 178 FULTON STREET;
(SUCCESSORS OF NEWMAN & IVISON, AND MARK H. NEWMAN & CO.)
CHICAGO: S. C. GRIGGS & CO. BUFFALO: PHINNEY & CO.
AUBURN: J. C. IVISON & CO. DETROIT: A. M'FARREN.
CINCINNATI: MOORE, ANDERSON & CO.

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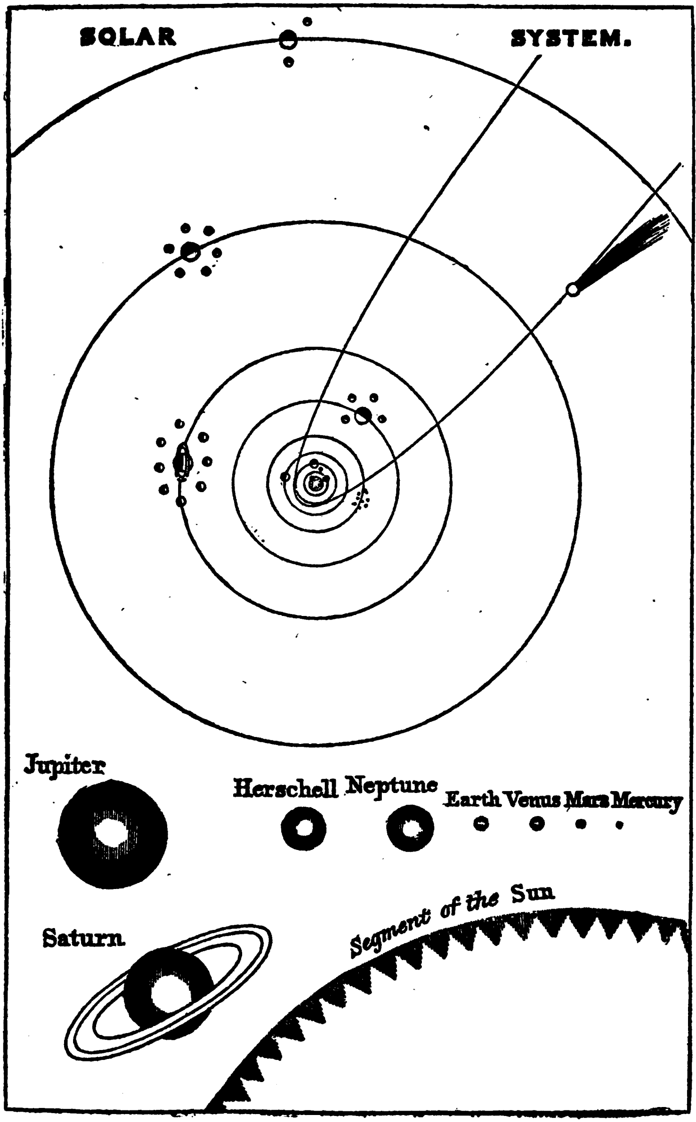
SOLAR SYSTEM.
Jupiter
Herschell
Neptune
Earth
Venus
Mars
Mercury
Saturn
Segment of the Sun

Marie Barnes

Mrs. A. E. Foster

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PREFACE.

This little work, on the subject of Astronomy, has been prepared to supply a deficiency which the author has himself experienced, in teaching the elements of this interesting and useful science, and which has been a subject of complaint with many other teachers. The books that have hitherto appeared on the subject, though by no means few, have either been meagre in facts, or have represented them in a manner neither well-arranged, nor adapted to their purpose as class-manuals. Some have, indeed, been excellent treatises on the subject; but, making no distinction between definitions, or facts, and the matter intended to explain them, could not be conveniently used by either teacher or pupil.

The work here offered to teachers, is designed to remedy both of the defects here mentioned. It professes to give a sufficient number of facts for an elementary treatise, accompanied occasionally by diagrams and brief explanations, which will serve at least to give a hint to the teacher, and afford him the means of adding farther illustration. Works much more profusely illustrated scarcely ever do more, while very often the pupil receives from the fanciful representations, contained in them, a very erroneous idea of the subject, and the expense of the book is unnecessarily increased.

The plan of dividing the subject of each chapter into short and distinct paragraphs, each the answer to a question inserted at the bottom of the page, is, as far as the author is aware, original in a school treatise, on this subject, and has, he thinks, several advantages over the method of giving question and answer together. In the first place, the questions must, very often, contain the most important part of what the pupil should commit; secondly, the pupil, by confining his attention almost wholly to the answer, learns the definition or fact imperfectly; and thirdly, the insertion of the questions with the answer, increases unnecessarily the size and expense of the work.

The introduction of questions, where possible, which the pupil is to answer from his acquired knowledge of the subject, and not by rote, is a feature which the author has seen in no other work on the subject.

Most of our Elementary Astronomies pay little or no attention to the use of the artificial globes. The schools are generally supplied with globes, which, for the want of a manual on the subject, serve only to adorn the school-room. The pupil is, by this means, deprived of one of the best means of illustrating the subject, as well as of much practical information, which the use of the globe would indelibly impress upon his mind. This deficiency the author has endeavored to supply, by the second part of the work, which may, without difficulty, be studied in connection with the first. This portion of the work has been made more extensive than is generally found in elementary treatises, without comprehending what could only be expected in a treatise of a higher character.

Another motive has also induced the preparation of this work. The author has seen, with regret, that many persons, at the present time, appear to regard this science as unimportant or unsuitable to our Common Schools. Without entering into any argument to show the contrary, it will suffice to say, that a science whose progress is the peculiar glory of modern times,—which, in an important manner, illustrates geography,—which is necessary to the navigator, —which teaches the true character and position of our own world, as well as the character of the universe, of which it forms a part,— and which imparts to the mind of the student, a true and sublime idea of the character and power of the Almighty Creator thereof,— can scarcely be less important than the science which teaches localities on the earth, or associates with them the memory of the follies, the vices, and the wars of mankind.

If this little book shall be found acceptable to teachers, as an auxiliary in imparting instruction in this truly sublime science, the author will esteem himself well rewarded for the labor of preparing it.

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INTRODUCTION.

HISTORY OF ASTRONOMY.

Astronomy is supposed to be the most ancient of sciences. The sublime spectacle of the starry heavens, would naturally, at a very early age, attract the attention and excite the admiration of the most careless or ignorant observer; and the curiosity of mankind would be early aroused to ascertain the nature of those "refulgent lamps" which lend so much splendor and beauty to the otherwise sombre gloom of night. Accordingly, it is stated that shepherds and herdsmen were the first who endeavored to explore the wonders of that magnificent scene which their occupation obliged them to survey, from year to year, while watching their flocks by night, under the open sky. The shepherds of Chaldea, and the priests of Egypt and India, had, in remote antiquity, made some progress in astronomical discovery. They had, it is said, calculated the length of the solar year with tolerable correctness, and could even predict, within a certain time, the occurrence of solar and lunar eclipses. From these countries, too, we are told, Pythagoras, a Grecian philosopher, about 500 years before the Christian era, obtained a knowledge of the true solar system, which he published, at that time, in Greece and Italy. But though astronomy thus early engaged the attention of men, there is no science on which more false and absurd ideas were entertained, in ancient and even in modern times, up to comparatively a very recent date. Unacquainted with the true method of astronomical research, and destitute of instruments with which to make the necessary observations, the progress of the ancients towards a just conception of the nature of the heavenly bodies, and the true system of the universe, was exceedingly slow. As they trusted to the fallacious evidence of their senses alone, they were often bewildered in a labyrinth of conjecture, and frequently entertained the most absurd and extravagant conceptions to account for the phenomena presented to their view. The system of Pythagoras, being entirely at variance with these conceptions, was believed only by a very few; while, by the majority of mankind, it was entirely rejected, and therefore soon fell into neglect and forgetfulness.

Respecting the shape of the earth, and the means by which it is sustained in space, even the learned men of antiquity entertained the most wild and extravagant ideas. While a very few vainly endeavored to prove its rotundity, it was generally supposed to be a vast circular plane, supported in an incomprehensible manner, according to some, by a huge serpent, tortoise, or elephant. Some fancifully ascribed to it the shape of a cylinder, others that of a canoe; while the learned and accomplished Aristotle, a prodigy of genius, asserted that its figure is that of a timbrel,—showing in what an abyss of folly, even the most talented men may plunge themselves, when they leave the true path of scientific research, the patient observation of facts, to indulge in vain and idle speculation.

The first observations, of importance, were made at Alexandria, in Egypt, about 300 years before Christ, when the positions of several of the zodiacal stars were correctly defined. It was not, however, until 160 years later, that any further progress of importance was made. Hipparchus, the founder of Grecian astronomy, flourished at Rhodes, 140 years before Christ; and, as he discarded the idle and absurd notions generally entertained, and carefully observed and recorded the places and appearance of the heavenly bodies, he made many valuable discoveries, and became justly pre-eminent among ancient astronomers.

He discovered the precession of the equinoxes, the eccentricity of the sun's apparent orbit, the parallax of the planets, and the time of the moon's sidereal and synodical revolutions; defined the length of the solar and tropical year, and determined the places of more than a thousand of the fixed stars. He, moreover, invented the artificial sphere, and divided the heavens into 49 constellations, placing 12 in the zodiac, 21 in the northern, and 16 in the southern hemisphere. He was also the first who employed latitude and longitude to define the position of places on the surface of the earth.

About 250 years after Hipparchus, flourished the celebrated Ptolemy. He published several works, containing everything then known of the science of astronomy, and, in one of them, explained a new and original theory of the planetary motions, invented by himself, and called after him, the Ptolemaic system.

It supposed the earth to be fixed immovably in the centre of the universe, while all the heavenly bodies revolve around it, in the following order: the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the stars. Each of these bodies, he supposed, was set in a hollow, crystalline sphere, perfectly transparent, by which it was carried around the earth, and prevented from falling upon it. This system, though so manifestly absurd and erroneous, was universally believed to be true until the sixteenth century.

In the year 1543, Copernicus, a Prussian astronomer, and a man of a comprehensive and original genius, published a work on the motions of the celestial orbs, in which he revived the long-neglected system of Pythagoras, confuting, by a variety of arguments, the false supposition of all the bodies revolving around the earth every day, and boldly asserting the rotation of the earth on its axis. This work was respected but by very few, while it was generally rejected, and contemned as chimerical and absurd. Its most distinguished opponent, however, was Tycho Brahe, an eminent Danish nobleman, who was born in 1546, and devoted the whole of his life to his favorite science, astronomy. He carried the use of instruments to a greater extent than any previous astronomer, and accumulated a vast store of facts and statistics relating to the heavenly bodies. Unfortunately, he was unable to agree with Copernicus, as to the true system of the world, and he therefore invented and published, in opposition to him, an original system, called after himself, the Tychonic system. In this system, the earth is placed in the centre of the universe, with the sun, moon, and stars revolving around it, while the planets revolve around the sun, and are carried with it around the earth. It was adopted by scarcely any except the astronomer's own pupils.

Galileo, in 1610, availing himself of the invention of the telescope, was enabled to make several important discoveries, by which the rotation of the earth on its axis was fully confirmed, and the hypothesis of Tycho Brahe exploded. Such, however, was the ignorance of the age, that it was deemed irreligious to believe in the doctrine of the earth's motion, and Galileo, in his seventieth year, was obliged publicly to acknowledge himself in error, and, contrary to his own convictions, deny the fact of its rotation. But the truth could not long be crushed. The great Kepler arose, and, profiting by the vast stores which the labors of Tycho Brahe had accumulated, after many years of patient and incessant study, he arrived at those brilliant discoveries, called "Kepler's laws."

In the latter part of the seventeenth century, Sir Isaac Newton, by making known the law of universal gravitation, set the seal of confirmation upon the labors and teachings of the eminent men who had preceded him, and prepared the way for the brilliant discoveries of more modern times. Since that period, the science has rapidly and steadily progressed from year to year, filling men's minds with admiration and amazement at the sublime and startling facts which have been successively made known by its votaries. Among the many illustrious men who have devoted their lives to this pursuit, the names of Herschell and Le Verrier deserve particular commemoration, as the discoverers of the two most distant planets of the solar system. In addition to these two bodies, fifteen minor planets or asteroids have been discovered between Mars and Jupiter, during the present century, while astronomers, in addition to these achievements in our own system, have passed beyond, into the illimitable fields of space, and revealed many of the wonders of the starry universe. The achievements of astronomy are truly astonishing, and furnish the most striking illustration of what can be accomplished by the faculties of man, feeble as they are, when constantly and systematically directed upon the investigation of any subject.

PART I.

CHAPTER I.

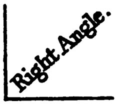
MATHEMATICAL DEFINITIONS.

An Angle is the inclination of two lines which meet in a point.

Angles are of three kinds; right, obtuse, and acute.

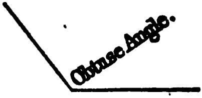
A right angle is one formed by one line meeting another perpendicularly, and contains 90 degrees.

Fig. 1.



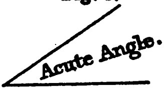
An obtuse angle is an angle greater than a right angle, and contains more than 90 degrees.

Fig. 2.



An acute angle is one less than a right angle, and contains less than 90 degrees.

Fig. 3.

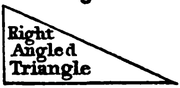


Parallel lines are such as, being extended, will never meet. They may be either straight or curved.

Fig. 4.

What is an angle? Of how many kinds are angles? What is a right angle? What is an obtuse angle? What is an acute angle? What are parallel lines?

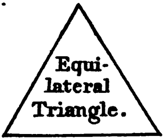
Fig. 5.



A triangle is a figure bounded by three sides.

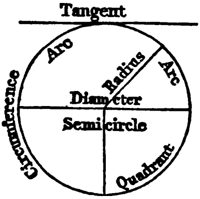
A right-angled triangle is one which contains a right angle.

Fig. 6.



An equilateral triangle is one which has equal sides.

Fig. 7.



A circle is a figure bounded by a curve line, every part of which is equally distant from the centre.

The circumference is the curve line that bounds it.

The diameter is a straight line drawn through its centre from one point of the circumference to another.

The radius is a straight line drawn from the centre to the circumference.

An arc is any part of the circumference.

A tangent is a line which touches the circumference in one point.

The circumference of every circle is supposed to be divided into 360 degrees, each degree into 60 minutes, and each minute into 60 seconds.

A semicircle is one half of a circle, and contains 180 degrees.

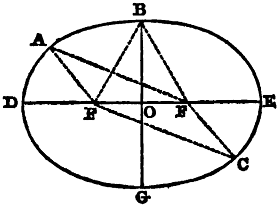
What is a triangle? What is a right-angled triangle? What is an equilateral triangle? What is a circle? What is the circumference? What is the diameter? What is the radius? What is an arc? What is a tangent? How is the circumference of every circle supposed to be divided? What is a semicircle?

A quadrant is a quarter of a circle, and contains 90 degrees.

An ellipse is a curve line, from any point of which, if two straight lines be drawn to its foci, their sum will be always the same.

Thus in the ellipse D B E G, F and F represent the foci, to which, if straight lines be drawn, whether from A, B, or C, the sum of each pair will be always the same.

Fig. 8.



The longest diameter of an ellipse is called the major axis, and its shortest diameter the minor axis.

Thus in the Figure, D E is the major axis, and B G the minor axis of the ellipse.

A sphere or globe is a round body, every part of the surface of which is equally distant from a point within called the centre.

A hemisphere is a half of a globe.

The diameter of a sphere is a straight line drawn through the centre, terminated both ways by the surface of the sphere.

The radius of a sphere is a straight line drawn from the centre to the surface.

Circles drawn on the surface of a sphere are of two kinds, great and small.

Great circles are those which divide the globe into two equal parts.

What is a quadrant? What is an ellipse? What are the longest and shortest axes called? What is a sphere? What is a hemisphere? What is the diameter of a sphere? What is the radius of a sphere? Of how many kinds are circles, drawn on the sphere? What are great circles?

Small circles are those which divide the globe into two unequal parts.

The poles of a great circle, are two opposite points on the surface of the sphere, equally distant from every part of its circumference.

An oblate spheroid is a sphere flattened at the poles.

The plane of a figure, is the imaginary even surface on which it may be supposed to be described.

Circles drawn on the surface of a sphere, are parallel when their planes are parallel.

CHAPTER II.

THE HEAVENLY BODIES.

ASTRONOMY is the science which treats of the heavenly bodies.

The heavenly bodies consist of the Sun, Planets, Comets, and Stars.

They may be divided into two general classes, Luminous and Opaque bodies.

Luminous bodies are those which shine by their own light.

What are small circles? What are the poles of a great circle? What is an oblate spheroid? What is the plane of a figure? When are circles of the sphere parallel?

What is astronomy? Of what do the heavenly bodies consist? How may they be divided? What are luminous bodies?

Opaque bodies are those which shine only by light received from some luminous body.

The sun and stars are luminous bodies.

The planets and comets are opaque bodies.

A system, in astronomy, is a certain assemblage of heavenly bodies.

The Solar System is that which consists of the sun, with the planets and comets revolving around it.

Planets are opaque bodies, which revolve around the sun.

They are of two kinds, primary and secondary.

Primary planets are those which revolve around the sun only.

Secondary planets are those which revolve around their primaries, and, with them, around the sun.

Secondary planets are sometimes called Satellites.

There are eight primary planets in the solar system, viz., Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Herschell or Uranus, and Neptune or Leverrier, besides the minor planets or Asteroids.

There are twenty-one secondary planets, viz., the Earth has one, Jupiter four, Saturn eight, Uranus six, and Neptune two.

Mercury and Venus are called inferior planets, because their orbits are within that of the earth.

Mars, Jupiter, Saturn, Uranus, and Neptune, are called

What are opaque bodies? What bodies are luminous? What bodies are opaque? What is a system? What is the solar system? What are planets? Of how many kinds are planets? What are primary planets? What are secondary planets? What are they sometimes called? How many primary planets are there? How many secondary? Which are the inferior planets? Which are the superior?

superior planets, because their orbits are outside that of the earth.

The Asteroids are small planets which revolve around the sun, between the orbits of Mars and Jupiter.

They are fifteen in number, viz., Vesta, Juno, Ceres, Pallas, Astraea, Iris, Hebe, Flora, Metis, Hygeia, Parthenope, Clio, Egeria, Irene, and Eunomia.

Comets are bodies which revolve around the sun in very elongated orbits, and are generally accompanied by a long train of light.

The Stars are those bodies which appear never to change their positions with respect to each other.

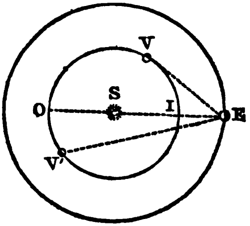
They are, for this reason, called Fixed Stars.

The Orbit of a planet, is the path in which it revolves around the sun or central body.

The plane of the earth's orbit is called the Ecliptic.

The Elongation of any body, is its angular distance from the sun.

Fig. 9.



Thus, if E represent the earth in its orbit, and V, or V′, Venus in its orbit, the angle V E S, or V′ E S, will represent the elongation of Venus at either of the two points. At I and O, it will be seen the elongation is nothing, while at V it is greatest.

A body is said to be in Conjunction with the sun, when it appears in the same part of the heavens.

Conjunction is of two kinds, Inferior and Superior.

What are the asteroids? How many are there? Name them. What are comets? What are the stars? What are they called? What is the orbit of a planet? What is elongation? When is a body said to be in conjunction?

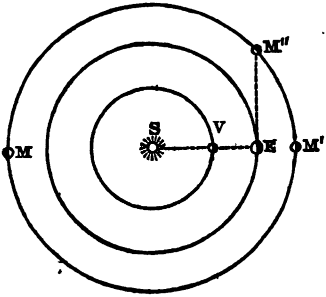
Inferior conjunction is when the body is between the earth and the sun.

Superior conjunction is when the body is on the opposite side of the sun from the earth.

A body is said to be in Opposition, when the sun and body are on opposite sides of the earth.

A body is said to be in Quadrature with the sun, when it is 90 degrees distant from it.

Fig. 10.



Thus V represents Venus in inferior conjunction; M, Mars in superior conjunction; M', Mars in opposition; and M'', the same planet in quadrature. Its angular distance, or elongation, S E M,'' being a right angle.

The Disc of a body is the circular illuminated surface which it presents to our view.

A Digit is the twelfth part of the diameter of the disc.

The Axis of a body, is an imaginary line around which it revolves.

Diurnal rotation is the revolution of a body on its axis, and is called its day.

Annual revolution is the revolution of a body around the sun, and is called its year.

The Mass of any body, is the quantity of matter which it contains.

What is inferior conjunction? What is superior conjunction? What is opposition? What is quadrature? What is the disc of a body? What is a digit? What is the axis of a body? What is diurnal rotation? What is annual revolution? What is the mass of a body?

The Density of any body, is the degree of compactness of its substance.

The Angular diameter of a body, is its apparent diameter, expressed in minutes and seconds, as seen from the earth.

The Linear diameter is its actual diameter.

The heavenly bodies are, in general, *oblate spheroids.*

QUESTIONS FOR EXERCISE.

What is the elongation of a body in quadrature?

What is the elongation of a body in inferior conjunction?

What is the elongation of a body in superior conjunction?

What is the elongation of a body in opposition?

What bodies can be in inferior conjunction?

What bodies can be in superior conjunction?

What bodies can be in opposition?

What bodies can be in quadrature?

Can the elongation of Venus exceed 90 degrees? (Fig. 9.)

Can that of Mercury?

Can that of Jupiter?

What is the greatest elongation of Mars?—Saturn?—Neptune?

When Venus is in inferior conjunction, and Mars in opposition, what is the angular distance between the two bodies?

What is the angular distance of one from the other, if Venus is in inferior conjunction, and Mars in superior conjunction?

What is their angular distance, when Venus is in superior conjunction, and Mars in quadrature?

What is the density? What is the angular diameter? What is the linear diameter? What is the shape of the heavenly bodies?

CHAPTER III.

PLANETARY MOTIONS.

ALL the planets move in their orbits from *west* to *east*.

A planet's revolution in its orbit, is sustained by the united action of two forces, viz., the Centripetal and Centrifugal forces.

The Centripetal force is that which draws a body towards the centre, or body around which it is revolving.

It is also called the *attraction of gravitation*, being, in fact, the power which all bodies possess, of mutually attracting each other.

The Centrifugal force is that by which a body tends to fly off from the orbit in which it is revolving.

It increases with the velocity of the body.

Laws, in astronomy, are general and invariable facts respecting the motions of the heavenly bodies.

The following are the three great laws of planetary motion, discovered by Kepler, and hence called *Kepler's laws:*

1. The planets' orbits are ellipses, having the sun or central body in one of the foci.

2. The radius-vector of a planet's orbit, passes over equal spaces in equal times.

In what direction do the planets move in their orbits? How is a planet's revolution in its orbit sustained? What is the centripetal force? What is this force also called? What is the centrifugal force? How does it increase? What are laws in astronomy? Recite Kepler's laws.

3. The squares of the periodic times, are in proportion to the cubes of the mean distances from the sun.

The Radius-vector of a planet's orbit, is a line drawn from the central body to any point of the orbit.

The Eccentricity of a planet's orbit, is the distance from the centre to either of the foci.

The Aphelion is that point of a planet's orbit which is farthest from the sun.

The Perihelion is that point of its orbit nearest to the sun.

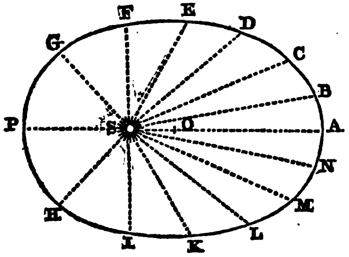
The point of the moon's orbit farthest from the earth is called the Apogee.

The point nearest to the earth is called the Perigee.

These two points are also called the Apsides.

The line which joins them, is called the Apsis line, or line of Apsides.

Fig. 11.



Let the annexed diagram represent the orbit of a planet, S being the sun, in one of the foci, and O the centre of the orbit. Then the distance S O will represent the eccentricity; the point A the aphelion; the point P the perihelion; A and P the apsides; and the line connecting them the apsis line. The lines B S, C S, D S, &c., represent the radius-vector in different positions, the spaces between them being supposed to be all equal to each other, and, according to the first law, passed over in equal times. The planet would, therefore, move over P G in the same time as A B, and thus its velocity is greatest at the perihelion, and least at the aphelion.

The difference is not, however, in the case of any of the planets, so great as

What is the radius-vector? What is eccentricity? What is the aphelion? What is the perihelion? What is the apogee? What is the perigee? What are these two points also called? What is the apsis line?

represented in the diagram. The difference of the earth's hourly angular velocity, at the aphelion and perihelion, is only about four minutes, and its eccentricity, S O, only about 1-59 of its semi-axis, A O, so nearly does its orbit resemble an exact circle.

The velocity of a planet is increased or diminished, as it approaches or recedes from the sun.

Of any two planets, that which is nearest to the sun moves with the greatest velocity.

The planets' orbits are all inclined to the ecliptic, and cross it in two points.

The Nodes are the two opposite points, where the orbit of a planet cuts the ecliptic.

The Ascending Node is the point, at which the planet crosses the ecliptic from south to north.

The Descending Node is the point, at which the planet crosses the ecliptic from north to south.

The True place of a planet, is the place at which it is actually situated.

The Mean place is that in which it would be, if it moved uniformly in a circle.

When is a planet's velocity increased and diminished? Which planet moves with the greatest velocity? What is the position of the planets' orbits? What are the nodes? What is the ascending node? What is the descending node? What is the true place of a planet? What is the mean place?

TABLE OF MAGNITUDES, DISTANCES, AND REVOLUTIONS OF THE PRIMARY PLANETS.

NAME.	Diameter.	Distance from the Sun.	Annual Revolution.		Diurnal Rotation.	
	Miles.	Miles.	Years.	Days.	Dys.	Hrs.
Sun . .	887,000				25	10
Mercury .	3,200	37,000,000		88		24
Venus . .	7,700	68,000,000		224		23½
Earth . .	7,912	95,000,000		365¼		24
Mars . .	4,200	142,000,000	1	321		24½
Jupiter . .	89,000	485,000,000	11	314		10
Saturn . .	79,000	890,000,000	29	170		10½
Uranus .	35,000	1,800,000,000	84	5		9½
Neptune .	31,000	2,850,000,000	164	225		

TABLE OF ASTEROIDS.

NAME.	Diameter.	Distance from the Sun.	Annual Revolution.	
	Miles.	Miles.	Years.	Days.
Flora		210,000,000	3	98
Vesta	270	225,000,000	3	230
Iris		227,000,000	3	250
Metis		227,000,000	3	251
Hebe		231,000,000	3	285
Astræa		245,000,000	4	51
Juno	1,400	254,000,000	4	134
Ceres	1,600	263,000,000	4	222
Pallas	2,100	263,500,000	4	226
Hygeia		298,000,000	5	199
Parthenope . .		234,000,000	3	305
Clio		222,000,000	3	206
Egeria		245,000,000	4	44
Irene		246,000,000	4	54
Eunomia . . .		252,000,000	4	113

What is the diameter of the sun? What is the time of its diurnal rotation? Mention the diameter of each of the primary planets? State the distance of each from the sun? What is the time of the annual revolution of each? What is the time of the diurnal rotation of each? What is the diameter of each of the asteroids as far as known? What the distance from the sun? What the period of annual revolution?

CHAPTER IV.

THE DOCTRINE OF THE SPHERE.

SECTION I.

THE artificial globes are two in number, viz., the Terrestrial and Celestial globes.

The Terrestrial globe represents the earth, with its natural and political divisions delineated on its surface.

The Celestial globe represents the sphere of the heavens, in the centre of which the earth appears to be placed.

The Constellations, together with the various circles used in astronomy, are laid down on its surface.

A Constellation is a number of stars included within a certain space.

The Axis of the earth, is an imaginary line around which it rotates.

The Poles of the earth, are two imaginary points at the extremities of its axis, and are called the North, or Arctic pole, and the South, or Antarctic pole.

The Celestial Poles are the extremities of the earth's axis extended to the heavens.

The principal great circles drawn on the sphere, are the Equator, the Ecliptic, and the Meridians.

How many and what are the artificial globes? What does the terrestrial globe represent? What does the celestial? What are laid down on its surface? What is a constellation? What is the axis of the earth? What are the poles of the earth? What are they called? What are the celestial poles? Mention the principal great circles.

SECTION II.

The Equator is a great circle whose plane divides the earth into northern and southern hemispheres.

Latitude, on the earth, is distance north or south from the equator.

It is reckoned on a meridian, from the equator to the poles.

The greatest latitude of any place on the earth, is 90 degrees.

Parallels of latitude are small circles parallel to the equator.

Their number is unlimited.

The Tropics are two small circles parallel to the equator, at the distance of 23½ degrees from it.

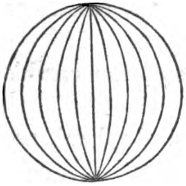
The Northern is called the tropic of Cancer, and the Southern the tropic of Capricorn.

The Polar circles are two small circles parallel to the equator, at the distance of 23½ degrees from the poles.

The Northern is called the Arctic circle, and the Southern the Antarctic circle.

Fig. 12.

Meridians

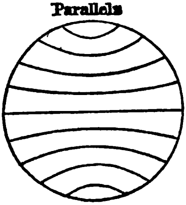


Meridians are great circles which pass through the poles at right angles with the equator.

Longitude is distance east or west from any established meridian.

What is the equator? What is latitude on the earth? How is it reckoned? What is the greatest latitude of any place? What are parallels of latitude? How many are there? What are the tropics? What are they called? What are the polar circles? What are they called? What are meridians? What is longitude?

Fig. 13.



The first meridian is that from which longitude is reckoned.

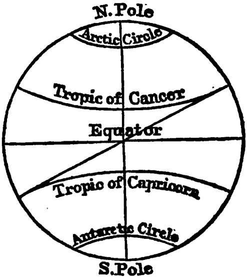
The meridian of London or Greenwich is generally employed as a first meridian.

The greatest longitude of any place on the earth, is 180 degrees.

SECTION III.—ZONES.

Zones are those divisions of the earth's surface which are bounded by the tropics and polar circles.

Fig. 14.



There are five zones, viz., one Torrid, two Temperate, and two Frigid zones.

The Torrid zone is that which is included within the tropics, the equator passing through the middle of it.

It is 47 degrees wide; 23½ degrees on each side of the equator.

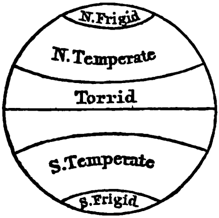
The North Temperate zone is that which is included within the tropic of Cancer, and the Arctic circle. It is 43 degrees wide.

The South Temperate zone is that included within the tropic of Capricorn and the Antarctic circle. It is 43 degrees wide.

What is the first meridian? What meridian is generally used as such? What is the greatest longitude of any place?

What are zones? How many, and what are they? What is the torrid zone? How wide is it? What is the north temperate zone? What is the south temperate [illegible] What is the width of each?

Fig. 15.



The North Frigid zone is that contained within the Arctic circle, having the north pole for its centre.

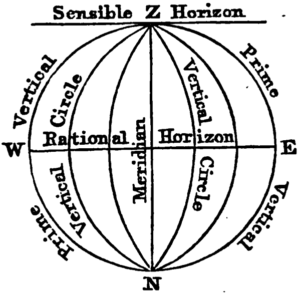
The South Frigid zone is that contained within the Antarctic circle, having the south pole for its centre.

The distance across each of the frigid zones, is 47 degrees, or 23½ degrees each side of the pole.

SECTION IV.—THE HORIZON.

The Horizon of any place, is the circle which separates the visible part of the heavens from the invisible.

Fig. 16.



There are two horizons, the Sensible and the Rational horizon.

The Sensible horizon is that *small* circle on the earth which bounds our prospect, where the earth and sky appear to meet.

The Rational horizon is a *great* circle which is parallel to the sensible horizon, and whose plane divides the earth into upper and lower hemispheres.

What is the north frigid zone? What is the south frigid? How many degrees across each of the frigid zones?

What is the horizon? How many horizons are there? What is the sensible horizon? What is the rational horizon?

The poles of the horizon, are called the Zenith and the Nadir.

The Zenith is that point which is exactly over our heads.

The Nadir is the point opposite to the zenith, or directly under our feet.

The cardinal points of the horizon are the North, East, South, and West.

Vertical circles are great circles which pass through the zenith and nadir, and cut the horizon at right angles.

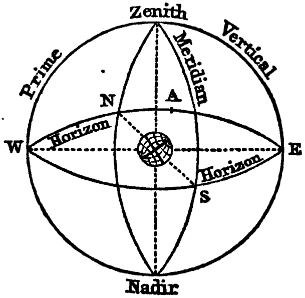
The Prime Vertical is that vertical circle which passes through the east and west points of the horizon.

The Meridian of a place corresponds to a vertical circle which passes through the north and south points of the horizon.

The Azimuth of a heavenly body, is its distance from the meridian, measured on the horizon.

The Amplitude of a heavenly body, is its distance from the prime vertical, measured on the horizon.

Fig. 17.



Thus, in Figure 17, let N E S W represent the plane of the horizon, N S the meridian, and W E the prime ver-

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What are the poles of the horizon called? What is the zenith? What is the nadir? What are the cardinal points of the horizon? What are vertical circles? What is the prime vertical? What is the meridian of a place? What is the azimuth of a heavenly body? What is the amplitude of a heavenly body?

tical; then, if A be the position of the sun at its rising, A E will represent its amplitude, and A N its azimuth.

The Altitude of a body, is its distance above the horizon, reckoned on a vertical circle.

The Zenith Distance of a body, is its distance from the zenith, reckoned on a vertical circle.

The Polar Distance of a body, is its distance from the pole, reckoned on a meridian.

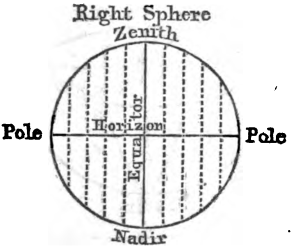
Circles of daily motion, are those circles which the heavenly bodies describe in their apparent daily revolution around the earth.

The Diurnal Arch is that part of a circle of daily motion which a heavenly body describes from its rising to its setting.

The Nocturnal Arch is that part which it describes from its setting to its rising.

The sphere, with respect to the circles of daily motion, has three positions, Right, Oblique, and Parallel.

Fig. 18.



A Right Sphere is that in which the circles of daily motion are perpendicular to the horizon.

A Parallel Sphere is that in which the circles of daily motion are parallel to the horizon.

An Oblique Sphere is that

What is altitude? What is zenith distance? What is polar distance? What are circles of daily motion? What is the diurnal arch? What is the nocturnal arch? How many positions has the sphere? What is a right sphere? What is a parallel sphere? What is an oblique sphere?

in which the circles of daily motion are oblique to the horizon.

Those who live under the equator have a right sphere, those at the poles a parallel sphere, and those between the equator and the poles an oblique sphere.

The circle of perpetual apparition, is that circle in which the stars never set.

The circle of perpetual occultation, is that in which the stars never rise.

Fig. 19.

Parallel Sphere

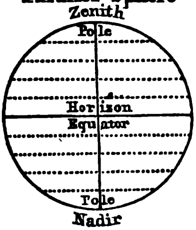
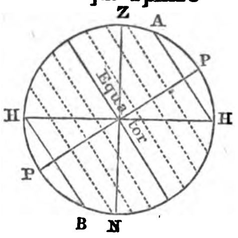


Fig. 20.

Oblique Sphere



Thus, in Fig. 20, A H represents the circle of perpetual apparition, and B H the circle of perpetual occultation. P H represents the altitude of the pole, which always corresponds to the latitude of the place. Thus the latitude of New York is 41 degrees north; hence the altitude of the north pole in that city, is 41 degrees, and the circle of perpetual apparition extends 41 degrees from the pole. The altitude of the equator or equinoctial, is always equal to the difference between the latitude of the place and 90 degrees. Consequently, the altitude of the sun at noon is always equal to the altitude of the equator, plus its north declination or minus its south declination, in the northern hemisphere; and plus its south or minus its north declination, in the southern hemisphere. These statements may be easily verified by an examination of the diagram.

What inhabitants of the earth have each? What is the circle of perpetual apparition? What is the circle of perpetual occultation?

SECTION V.—THE ECLIPTIC AND ZODIAC.

The Equator, when referred to the heavens, is called the Equinoctial.

The Ecliptic is a great circle drawn on the globe, in the plane of the earth's orbit, which it represents.

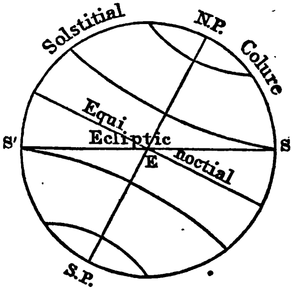
The Ecliptic intersects the Equinoctial at an angle of 23½ degrees.

The Cardinal points of the ecliptic, are the Equinoctial and Solstitial points.

The Equinoctial points are the two opposite points, at which the ecliptic and equinoctial intersect each other.

The Solstitial points are those points of the ecliptic, farthest from the equinoctial, or where it touches the tropics.

Fig. 21.



The Equinoctial Colure is the meridian which passes through the equinoctial points.

The Solstitial Colure is the meridian which passes through the solstitial points.

Thus, in Fig. 21, S and S' represent the solstitial points, and E one of the equinoctial points, the other being in the hemisphere not represented in the diagram.

The Zodiac is a zone or belt 16 degrees wide, encom-

What is the equinoctial? What is the ecliptic? At what angle does the ecliptic intersect the equinoctial? What are the cardinal points of the ecliptic? What are the equinoctial points? What are the solstitial points? What is the equinoctial colure? What is the solstitial colure? What is the zodiac?

passing the globe, at the distance of eight degrees on each side of the ecliptic.

The planets, except most of the Asteroids, move within the zodiac.

The ecliptic and zodiac are divided into twelve equal parts, called Signs. Each sign contains 30 degrees.

The course of the sun, in his apparent yearly revolution around the earth, is indicated by these signs.

The sun appears to move, from west to east, through each sign successively,—while the earth passes through the opposite sign.

This apparent motion is caused by the real revolution of the earth, in its orbit, around the sun.

The following are the names of the signs, and the day on which the sun enters each of them:

Spring signs.	Aries	♈	Twenty-first of March.
	Taurus	♉	Twentieth of April.
	Gemini	♊	Twenty-first of May.
Summer signs.	Cancer	♋	Twenty-first of June.
	Leo	♌	Twenty-third of July.
	Virgo	♍	Twenty-third of August.
Autumnal signs.	Libra	♎	Twenty-third of September.
	Scorpio	♏	Twenty-third of October.
	Sagittarius	♐	Twenty-third of November.
Winter signs.	Capricornus	♑	Twenty-second of December.
	Aquarius	♒	Twentieth of January.
	Pisces	♓	Eighteenth of February.

What bodies move within it? How are the ecliptic and zodiac divided? What is indicated by the signs? How does the sun appear to move? What is this apparent motion caused by? Mention the names of the signs, and the day on which the sun enters each.

The Equinoctial points are the first degree of the sign Aries, called the Vernal equinox, and the first degree of Libra, called the Autumnal equinox.

The Solstitial points are the first degree of Cancer, called the Summer solstice, and the first degree of Capricorn, called the Winter solstice.

The sun passes the equinoctial points on the 21st of March, and the 23d of September.

It passes the solstitial points on the 21st of June, and the 22d of December.

The Latitude of a heavenly body, is its distance north or south from the ecliptic.

This is called Celestial Latitude.

Celestial Longitude is distance on the ecliptic, reckoned from the first degree of Aries, eastward round the globe.

The greatest longitude of a heavenly body, is 360 degrees.

The Declination of a heavenly body, is its distance north or south from the equinoctial.

Declination corresponds to latitude on the earth.

The Right Ascension of a heavenly body, is its distance from the first degree of Aries, reckoned on the equinoctial eastward round the globe.

The greatest right ascension of a heavenly body, is 360 degrees.

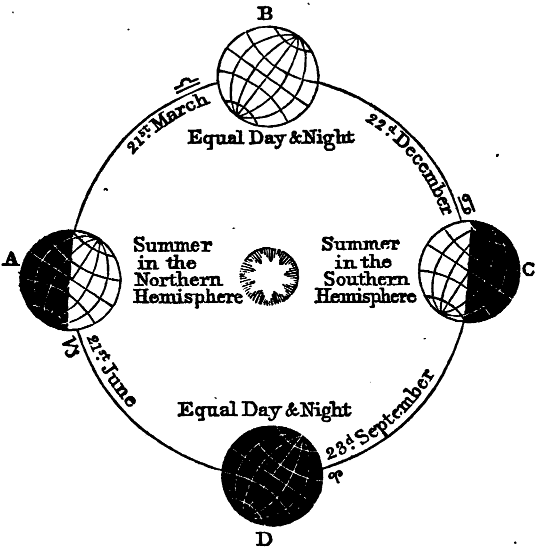
Where are the equinoctial points, and what are they called? Where the solstitial, and how named? When does the sun pass the equinoctial points? When the solstitial? What is the latitude of a heavenly body? What is this called? What is celestial longitude? What is the greatest longitude of a heavenly body? What is declination? To what does it correspond? What is right ascension? What is its greatest amount?

The sun is said to be vertical to a place, when it is directly over that place.

SECTION VI.—DAY AND NIGHT, SEASONS, &c.

The succession of day and night, is occasioned by the rotation of the earth on its axis.

Fig. 22.



In Figure 22, it will be seen, that the axis of the earth, in the positions A, B, C, and D, points in the same direction; and that at A and C, each pole is presented alternately to the sun; while at B and D, the axis leans sidewise to it, and both polar circles are equally illuminated. The following statements will be understood, from an inspection of this diagram:

When is the sun said to be vertical to a place?
By what is the succession of day and night occasioned?

The change of the seasons, is caused by the inclination of the earth's axis to the ecliptic, and its revolution around the sun.

The change of the seasons is regular, because the earth's axis always points in the same direction.

When the Sun enters Cancer, the north pole is presented to the Sun; and summer is produced in the Northern hemisphere, and winter in the Southern.

When the Sun enters Capricorn, the south pole is presented to it; and winter is produced in the Northern hemisphere, and summer in the Southern.

When the Sun enters Aries, the earth's axis leans sidewise to it; and spring is produced in the North temperate zone, and autumn in the South.

When the Sun enters Libra, the earth's axis leans sidewise to it; and autumn is produced in the North temperate zone, and spring in the South.

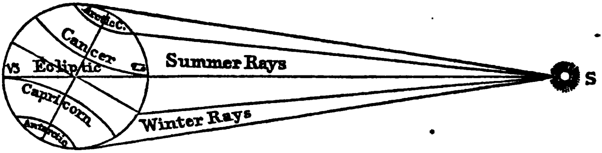
Summer is produced in either hemisphere, by the rays of the sun striking that part of the earth directly, so that they are collected on a smaller surface.

Winter is produced by the sun's rays striking a portion of the earth obliquely, so that the same amount of light and heat are spread over a greater surface.

This will be evident, from an inspection of Figure 23, in which it will be seen, that the same quantity of rays that covers the north polar circle, covers the south temperate zone, and half the torrid zone; the rays in the north temperate zone being direct, in the other oblique.

By what is the change of the seasons caused? Why is this change regular? When the sun enters Cancer, what are the effects? When the sun enters Capricorn, what effects are produced? When the sun enters Aries, what are the effects? When the sun enters Libra? What produces summer? What produces winter?

Fig. 23.



When the Sun is in either of the Equinoxes, the days and nights are equal, in every part of the earth.

When the Sun is in either of the Solstices, all places in the same hemisphere have their longest day, and those in the other their shortest day.

Places situated at either of the Poles, have continual day, during the whole six months the sun is in the same hemisphere; and continual night, during the six months it is in the other.

All places in the Frigid zones, have their day longer, or shorter, in proportion to their distance from the pole.

The Antoeci are those people who live under the same meridian, and in the same degree of latitude, on the opposite side of the equator.

The Perioeci are those who live in the same latitude, but in opposite longitude.

The Antipodes are those who live diametrically opposite to each other.

Their latitude and longitude, seasons, and day and night, are contrary to each other.

When the sun is in either of the equinoxes, what is the effect on the day and night? What, when the sun is in either of the solstices? What is said of places at either of the poles? How is the day, at places in the frigid zone, proportioned? What are the Antoeci? What are the Perioeci? What are the Antipodes? What is said of their latitude, etc.?

QUESTIONS FOR EXERCISE.

What is the latitude of the north pole?

What is the latitude of a place under the equator?

New York is about 49 degrees from the north pole, what is its latitude?

How far is it from the south pole?

What is the latitude of a place under the tropic of Cancer?

What, under the Antarctic circle?—What, under the tropic of Capricorn?

Which is the largest zone?—Which, the two smallest?

At which is the heat greatest?—At which, the cold?

What is the greatest altitude of a heavenly body?

Where is the altitude greatest?—Where is it nothing?

The zenith distance of a star is 15 degrees; what is its altitude?

The altitude of a star is 40 degrees; what is its zenith distance?

In what position of the sphere do the inhabitants of New York live?

How many degrees wide is the circle of perpetual apparition in the latitude of New York?—At the north pole?

How many degrees wide is it at the equator?

The declination of a certain star is 60 degrees north; does it ever set in New York?

Does it set in latitude 60° N.?—Does it rise in latitude 40° S.?

What is the greatest latitude of the sun?—Of a primary planet?—Of a star?

What is the greatest declination of the sun?—Of a primary planet?—Of a star?

At what two points is the declination of the sun greatest?—At what points is its declination nothing?

What is the Right Ascension of the sun in the first degree of

Cancer?—What in the first degree of Capricorn?—What in the first degree of Libra?—What in the vernal equinox?

What is the longitude of the sun at each of these points?

Where is its longitude nothing?

When the sun is at either of the equinoctial points, what is its altitude, at noon, in New York?

What is its greatest altitude, in New York, during the year? —What is its least?

The declination of a certain star is 30 degrees north; what is its altitude when on the meridian in New York?—Its zenith distance?

What must its declination have been to be seen in the zenith?

When is it longest day in New York?—When in Washington?

When is it shortest day at New York?—At Cape Horn?

When are the days and nights equal in New York?—When in Boston?—When at the equator?

A star is seen on the meridian, in New York, at an elevation of 40 degrees; what is its amplitude, azimuth, and zenith distance?

◆

CHAPTER V.

THE SUN.

The Sun is a luminous body placed in the centre of the Solar System.

It dispenses light and heat to all its attendant bodies.

The Sun's Apparent diameter is about half of a degree, (32 min.)

What is the sun? What does it dispense? What is its apparent diameter?

Its Linear diameter is 887,000 miles.

The Sun has *three* revolutions; one, on its axis, in 25 days and a half; another, around the centre of gravity of the system;* and a third, around the centre of the universe.

The density of the Sun is only one fourth that of the Earth, being but little heavier than water.

The Disc of the Sun, on being examined with a telescope, exhibits certain dark spots, which are constantly varying in number, size, and appearance.

Though most of them are very small, yet some have been seen, more than 50,000 miles in diameter.

They are mostly confined to a zone extending thirty degrees, on each side of its equator.

Astronomers suppose the Sun to be an opaque body, surrounded by an atmosphere of luminous matter.

The spots are supposed to be openings in the luminous atmosphere, through which the dark body of the Sun becomes visible.

The spots appear to move across the disc of the Sun from east to west, occupying about two weeks in their passage.

What is its linear diameter? How many revolutions has it? What is its density? What does its disc exhibit? How large are the spots? To what part of the sun are they confined? What do some astronomers suppose the sun to be? What are the spots supposed to be? How do the spots appear to move?

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* The centre of gravity of any number of bodies, is that point around which they all balance each other. If we take a large body, and connect it by means of a rod with a small one, the centre of gravity of the two, will be that point of the rod, on which they can be equipoised or balanced.

This appearance affords a proof of the Sun's revolution on its axis from west to east.*

Light passes from the Sun to the earth with a velocity of 192,000 miles in a second, and reaches the Earth in about eight minutes.

Two theories have been advanced, respecting the nature of light:

1. That it is composed of exceedingly small particles of matter. This was the opinion of Sir Isaac Newton.

2. That it is occasioned by rapid vibrations in a very etherial fluid, pervading all space.

Many modern opticians of great eminence maintain the latter theory.

Light proceeds from the Sun, in straight lines, and in all directions.

The axis of the Sun, is nearly perpendicular to the plane of the Ecliptic, making with it an angle of about 82½ degrees.

What does this appearance prove? What is the velocity of light? How soon does it reach the earth? Mention the two theories respecting the nature of light. How does it proceed from the sun? What is the position of the sun's axis?

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* It may appear singular, at the first view, to infer an eastward rotation of the sun from an apparent westward motion of the solar spots. But it must be remembered, that the sides of the sun and earth presented to each other, at any time, are moving in opposite directions in space, though both bodies move in the same direction, in circular motion.

CHAPTER VI.

THE INFERIOR PLANETS.

The Inferior Planets are Mercury and Venus. 4 one

Mercury is the smallest of the eight primary planets, and the nearest to the Sun.

Mercury is rarely visible to the naked eye, because it is so near the Sun.

Its greatest Elongation is about 29 degrees.

The Velocity of Mercury in its orbit is 110,000 miles an hour.

The Inclination of Mercury's orbit, as well as its eccentricity, is greater than that of any other of the eight primary planets.

Its Density is also greater, being twice that of the Earth, or as heavy as lead.

Venus is the second planet from the Sun. one

The Orbit of Venus is nearly a circle, and is very little inclined to the Ecliptic.

The greatest Elongation of Venus is 47 degrees.

Venus is called the Morning Star, when it is west of the Sun, and rises before it.

It is called the Evening Star, when it is east of the Sun, and sets after it.

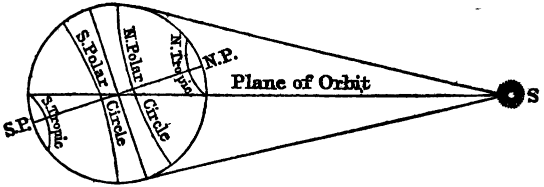
Which are the inferior planets? What is said of Mercury? Why is it rarely visible? What is its greatest elongation? What is its velocity in its orbit? What is said of the inclination of its orbit, and its eccentricity? What of its density? What is Venus? What peculiarities in its orbit? What is its greatest elongation? When is it called the morning star? When the evening star?

Venus is a Morning and an Evening Star alternately during 290 days. This is caused by the Earth's revolving round the Sun the same way.

The axis of Venus, makes an angle of 15 degrees with the plane of its orbit.

The Tropics of Venus, therefore, are 75 degrees from her Equator, which makes her Torrid Zone and Polar Circles, 150 degrees wide.

Fig. 24.



This will be easily understood, on inspecting the annexed diagram, which represents the sun in her northern tropic, when all places situated more than 15 degrees north of her equator, have constant day, and all more than 15 degrees south of it, constant night. This produces winter at the equator, and within the south polar circle, and summer within the north polar circle. In one fourth of her year, when the sun will have arrived at the equator, there will be equal day and night all over the planet, summer at the equator, autumn within the north polar circle, and spring within the south polar circle. As the sun arrives at the equator, and departs at its greatest distance from it, twice during the year, there must be two summers and winters, at that part of the planet, during a period of 224 days; and a summer and winter at each of the poles, which suffer a change from the burning heat of a vertical sun and constant day, to the intense cold of perpetual night.

The Phases of Mercury and Venus, when viewed through a telescope, appear similar to those of the Moon.

How long is Venus a morning and evening star alternately? How is this caused? What angle does its axis make with the plane of its orbit? How far are her tropics from her equator? How wide is her torrid zone and polar circles? What phases does Venus present?

The Transit of Mercury or Venus, is its passage across the Sun's disc.

A Transit takes place, when, at the time of inferior conjunction, the planet is at or near one of its nodes.

At the time of a Transit, Mercury or Venus appears like a small black spot, passing across the disc of the Sun.

This appearance affords a proof that they are opaque bodies.

The transits of Venus afford a method for calculating the distance of the Earth from the Sun.

The last transit took place in 1769; the next will occur in 1874.

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CHAPTER VII.

THE EARTH.

The Earth is the planet on which we live, and is the third from the Sun.

Its shape is an oblate spheroid, or very nearly a sphere.

Its Equatorial diameter, is about 7925 miles, and its Polar diameter is 26 miles less.

What is the transit of Mercury or Venus? When does a transit take place? How do Mercury and Venus appear during a transit? What does this prove? Why are the transits of Venus important? When did the last transit occur? When will the next?

What is the earth? What is its shape? What are its equatorial and polar diameters?

We have the following proofs that the Earth is a spherical body:

1. Navigators have sailed around it.

2. The top of a distant object at sea, is seen before any other part.

3. It casts a circular shadow on the disc of the moon, in a lunar eclipse.

The Earth is 96,000,000 miles from the Sun, in summer, and 94,000,000 miles in winter; its mean distance is 95,000,000 miles.

It is at its aphelion, July 1, and at its perihelion, January 1.

The Earth revolves around the Sun, from west to east, once every year.

It revolves on its axis, from west to east, once every 24 hours.

We have the following proofs that the Earth turns on its axis:

1. All the heavenly bodies, appear to revolve around the Earth, from east to west, every day.

2. The other primary planets are known to revolve on their axes.

3. The trade winds and ocean currents, can be accounted for in no other way.

The spheroidal shape of the Earth, is caused by its rotation on its axis.*

How is the earth proved to be spherical? How far is the earth from the sun? When is it at its aphelion and perihelion? In what time does it revolve around the sun? In what time on its axis? What proofs have we that the earth turns on its axis? What is the cause of the spheroidal shape of the earth?

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* The velocity of the equatorial parts of the earth, is more than 1000 miles an hour.

The Earth moves in its orbit with a velocity of 68,000 miles an hour.

The Density of the Earth is 5½ times that of water.

The Earth is attended by one satellite, called the Moon.

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CHAPTER VIII.

THE ATMOSPHERE OF THE EARTH.

THE Earth is surrounded by an elastic, invisible fluid, called Air.

The Earth's atmosphere consists of air, vapor, and many different gases.

Its height is estimated to be about 45 miles.

Air is composed of Oxygen and Nitrogen gases, in the proportion of 20 parts of Oxygen to 80 parts of Nitrogen.

Oxygen supports life, heat, and vegetation.

Air is 816 times lighter than water.

What is the earth's velocity in its orbit? What is its density? By what is it attended?

By what is the earth surrounded? Of what does its atmosphere consist? What is its height? Of what is air composed? What is said of oxygen? What is the weight of air?

This velocity diminishes, as we approach the poles, at which points it becomes nothing. The great velocity at the equator, occasions a much greater centrifugal force, at that part than at any other; in consequence of which, the water recedes from the poles, and accumulates at the equator, giving to the earth the shape mentioned in the text.

The pressure of the atmosphere is about 15 pounds to every square inch.

The Atmosphere becomes less and less dense, as we ascend from the surface of the Earth.

At the height of seven miles, it is only one fourth as dense as at the surface.

Clouds are condensed vapors floating in the air.

Wind is air put in motion.

Motion is produced in the atmosphere, by any portion of it becoming heated, and hence made lighter, so that it rises; and the heavier surrounding air, rushes in to fill its place.

Winds differ in their Direction, Force, and Duration.

The Trade Winds, are those which always blow in the same direction.

Their direction is from the north-east on the north side of the Equator; and from the south-east on the south side of the Equator.

They prevail between the Equator, and 30 degrees of north and south latitude.

Trade Winds are caused by the cold air rushing from the Poles to the Equator, together with the Earth's rotation on its axis.

Land and Sea Breezes, are those which blow one part of the day from the land, and another part from the sea.

They prevail in the islands of the Torrid zone.

What is the pressure of the atmosphere? When does the atmosphere become thinner? What is its density at the height of seven miles? What are clouds? What is wind? How is motion caused, in the atmosphere? How do winds differ? What are trade winds? What is their direction? Where do they prevail? By what are they caused? What are land and sea breezes? Where do they prevail?

Rain is occasioned by the clouds becoming condensed, and heavier than the air, so that they descend to the Earth.

Snow consists of particles of frozen vapor, which, being but a little heavier than the air, descend gently to the Earth.

Hail is produced by a sudden freezing of the drops of rain, when blown into the cold regions of the atmosphere.

Fogs and Mists are clouds resting on the surface of the Earth.

Fogs are caused by the warm vapors of the Earth's surface being condensed by the cold air above it.

Dew is moisture deposited by the air, upon a cold surface.

The following are some of the uses of the Earth's atmosphere:

1. It scatters and equalizes the light of the sun.
2. It supports life and vegetation.
3. It waters the soil of different countries, by means of rain, etc.
4. It affords a means of communicating sounds.

Most of the other planets are supposed to have atmospheres.

How is rain occasioned? What is snow? What is hail? What are fogs and mists? By what are fogs caused? What is dew? Mention some of the uses of the atmosphere. Have the other planets atmospheres?

CHAPTER IX.

THE MOON.

THE Moon is a Satellite of the Earth.

Its Diameter is about 2180 miles.

Its Apparent diameter is about one half of a degree.

Its Distance from the Earth is 240,000 miles.

The Moon revolves around the Earth, from west to east, in about 27⅓ days, (27 days, 7 h. 43 m.)

The Moon revolves upon its axis in exactly the same time that it revolves around the Earth.

The effect of this is, that the same hemisphere of the Moon is constantly turned towards the Earth.

The time which elapses between one New Moon and another, is 29½ days.

This period is longer than a complete revolution, because the Earth is revolving around the Sun the same way.

The time from one New Moon to another, is called a Synodical month.

The Moon's orbit is inclined to the ecliptic, at an angle of 5⅐ degrees.

The Axis of the Moon is nearly perpendicular to the

What is the moon? What is its diameter? What is its apparent diameter? How far is it from the earth? In what time does it revolve around the earth? In what time does it revolve upon its axis? What is the effect of this? What time elapses between one new moon and another? Why is this period longer than a complete revolution? What is this period called? At what angle is the moon's orbit inclined to the ecliptic? What is the position of her axis, and what seasons has she?

Ecliptic, consequently she experiences no change of seasons, except such as occur every month.

The Moon generally rises, about 50 minutes later every successive day.

The Moon rises later, because, as she advances eastward in her orbit, the Earth has to turn on its axis so much farther to overtake her.

Harvest Moon is the full moon, which occurs in September and October, when it rises only a few minutes later, for several successive evenings; and, thus affording light for collecting the harvest, is therefore called Harvest Moon.

Harvest Moon is caused by the Moon's orbit making a small angle with the Horizon, so that she descends but little below it, as she advances.

The Moon is one half of the Earth's diameter, or 4000 miles, nearer to us, when in the zenith, than when in the horizon.

Phases of the Moon, are the different appearances which she exhibits to our view.

New Moon occurs when she is in Conjunction, and the dark side is presented to us.

First Quarter is when, after conjunction, she is in Quadrature, and half of her disc is visible to us.

Full Moon is when she is in Opposition, and the whole of her disc is visible to us.

Last Quarter is when, after Full Moon, she is again in Quadrature, and exhibits only half of her disc.

Does the moon rise at the same hour every day? Why does she rise later? What is harvest moon? By what is it caused? Is the moon always at the same distance from us? What are the moon's phases? When does new moon occur? What is first quarter? What is full moon? What is last quarter?

When the Moon is between New Moon and Quadrature, and exhibits less than half of her disc, she is said to be Horned.

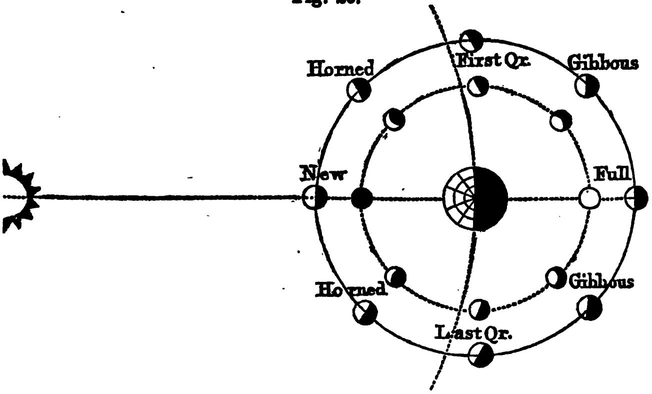
When she is between Quadrature and Opposition, and exhibits more than half, but not the whole of her disc, she is said to be Gibbous.

The phases of the Moon, are caused by different portions of her illuminated face, being turned towards the Earth.

The Moon's disc, when viewed through a telescope, presents a diversified appearance of dusky and bright spots.

The bright spots, are supposed to be mountains, and the dusky places, plains and valleys.

Fig. 25.



When is the moon said to be horned? When is she said to be gibbous? By what are the phases of the moon caused? How does the moon's disc appear, when viewed through a telescope? What are the bright spots? What the dusky spots?

Some of the mountains have been calculated to be about five miles in height.

The Moon is supposed to have very little, if any atmosphere; and, consequently, cannot be inhabited by beings like ourselves.

CHAPTER X.

MARS.

Mars is the fourth planet from the Sun, and is the smallest, except Mercury.

It is about one seventh of the size of the Earth.

The Axis of Mars is inclined towards its orbit about 30 degrees.

The Seasons, therefore, of Mars, resemble those of the Earth, but are nearly twice as long.

The Oblateness of Mars' figure is more than twenty times as great as that of the Earth.

Mars may be distinguished from the other planets, by its red, fiery color.

The Disc of Mars, when viewed with a telescope, exhibits the outlines of apparent continents and seas; the

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How high are the mountains in the moon? Has the moon any atmosphere? Is she inhabited?

What is Mars? What is its size? What is the inclination of its axis? What seasons has it? What is said of its figure? How may it be distinguished? What does its disc exhibit when viewed with a telescope?

continents appearing of a ruddy, and the seas of a greenish color.

The Disc of Mars also exhibits, brilliant white spots, alternately at each of the poles.

These spots are supposed to be accumulations of ice and snow; because they disappear at the pole as summer advances upon it.

The ruddy color of Mars is supposed to arise from a very dense atmosphere which surrounds it.

Mars is sometimes gibbous, but never horned; because it does not pass between us and the Sun.

CHAPTER XI.

JUPITER.

JUPITER is the largest planet in the Solar System.

It is about 1300 times as large as the Earth.

The Axis of Jupiter, is nearly perpendicular to its orbit, and it has, therefore, no change of seasons.

The Orbit of Jupiter, makes an angle of about one degree with the plane of the Ecliptic.

Jupiter is remarkable for the Oblateness of its figure, occasioned by its rapid rotation on its axis.

What does its disc also exhibit? What are these spots supposed to be? Why? What is the cause of the ruddy color of Mars? What phases does it exhibit? Why is it never horned?

What is Jupiter? What is its size? What is the position of its axis? What seasons has it? What is the inclination of its orbit? For what is Jupiter remarkable?

The Equatorial diameter of Jupiter is more than 6,000 miles greater than its Polar diameter.

The Velocity of the Equatorial parts of Jupiter is about 28,000 miles an hour.

The Density of Jupiter, like that of the Sun, is only one fourth that of the Earth, being but little heavier than water.

The Disc of Jupiter, when viewed with a telescope, exhibits dusky belts, parallel to each other, and at right angles with its axis.

The Belts of Jupiter, are supposed to be the dark body of the planet, seen between clouds in its atmosphere.

Jupiter is attended by four Satellites, all of which are larger than the Moon.

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CHAPTER XII.

SATURN.

SATURN is the sixth planet from the Sun, and is the largest except Jupiter.

It is 1,000 times as large as the Earth.

The Axis of Saturn inclines 28 degrees towards the plane of its orbit.

How much does its equatorial diameter exceed its polar? What is the velocity of its equatorial parts? What is its density? What does its disc exhibit? What are the belts supposed to be? By what is Jupiter attended? What is Saturn? What is its size? What is the inclination of its axis?

Its Seasons are, therefore, similar to those of the Earth, but about thirty times as long.

The figure of Saturn is remarkable for being flattened at the Equator as well as at the Poles, and presents the appearance of an irregular square.

The Density of Saturn is about one tenth as great as that of the Earth, being as light as cork.

Saturn is encompassed by two large Rings of solid matter.

These Rings are situated in the plane of its equator.

The following are their dimensions:

Breadth of inner ring, 17,000 miles.

Interval between this and outer ring, 1,800 miles.

Breadth of outer ring, 10,000 miles.

Distance from the planet to the inner ring, 19,000 miles.

The thickness of the rings, is supposed to be 100 miles.

They are proved to be opaque, by their casting a shadow on the planet, and receiving the shadow of the planet.

They revolve on an axis, in the same time as the planet.

The Disc of Saturn exhibits belts similar to those of Jupiter.

Saturn is attended by eight Satellites.

What seasons has it? How is its figure remarkable? What is its density? By what is Saturn encompassed? How are the rings situated? Recite their dimensions? What is the thickness of the rings? How are they known to be opaque? In what time do they revolve? What does the disc of Saturn exhibit? By how many satellites is Saturn attended?

CHAPTER XIII.

URANUS OR HERSCHEL.

Uranus is the seventh planet in the Solar System.

It was discovered in 1781, by Sir William Herschel.

Its magnitude is 85 times as great as that of the Earth.

It revolves on its Axis in about 9½ hours.

It is supposed to be attended by six Satellites; but only three of these are positively known to exist.

These Satellites revolve from east to west,—differing, in this respect, from all the other planets.

To an inhabitant of Uranus, the Sun appears no larger than Venus does to us,—its apparent diameter being only one minute and a half.

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CHAPTER XIV.

NEPTUNE OR LEVERRIER.

Neptune is the most distant planet known in the Solar System.

It was first observed, in 1846, by Dr. Galle, of Berlin.

The position of this planet was very nearly ascertained by Leverrier, a French mathematician, before its

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What is Uranus? When, and by whom, was it discovered? What is its magnitude? In what time does it revolve on its axis? By how many satellites is it attended? How do they revolve? How large does the sun appear at Uranus?

What is Neptune? When, and by whom, was it discovered? How and by whom was its position previously calculated?

actual discovery, by observing its action upon the planet Uranus.

Neptune is believed to be accompanied by two Satellites.

The light and heat of Neptune are 900 times less than at the Earth.

This planet was discovered under circumstances, which give a greater triumph to modern science, than any other discovery recorded in the annals of human knowledge. During several years previous, Uranus had been observed to deviate, in a mysterious manner, from the path assigned to it by the most careful calculations. Nothing but the supposition of another planet, existing somewhere in its vicinity, could account for the disturbance. Accordingly, two mathematicians, Mr. Adams, of England, and M. Leverrier, of Paris, undertook to calculate the position of this unknown planet. Both, though unknown to each other, arrived at conclusions differing but slightly. M. Leverrier, however, wrote to Dr. Galle, of Berlin, and requested him to direct his telescope to a certain point of the heavens. He did so, and the new planet was found within only *one degree* of the point specified by the mathematician.

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CHAPTER XV.

THE ASTEROIDS.

THE Asteroids are a number of small bodies revolving between the orbits of Mars and Jupiter.

The Asteroids are distinguished from the other primary planets, by the following circumstances:

1. Their orbits have a much greater inclination to the ecliptic; that of Pallas, making with it an angle of 34½ degrees.

By how many satellites is it accompanied? How much light and heat has it? What are the asteroids? How are they distinguished from the other planets?

2. Their orbits are much more eccentric, especially those of Juno and Pallas.

3. Their orbits, instead of being concentric, cross each other.

4. They revolve around the Sun, at very nearly the same distance from it, and in about the same time.

The magnitudes of these bodies have not been certainly ascertained; but they are supposed to be all smaller than the Moon.

Their average distance from the Sun, is about 260 millions of miles.

Their annual revolution is performed in about 4½ years.

All the Asteroids have been discovered during the present century. Ceres, Pallas, Juno, and Vesta, between 1801 and 1807; and the others since 1845.

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CHAPTER XVI.

APPARENT MOTIONS OF THE HEAVENLY BODIES.

ALL the heavenly bodies *collectively*, have two apparent revolutions around the earth; an Annual revolution rom *west* to *east*, and a Daily revolution from *east* to *west*.

The first of these is caused by the Annual revolution of the Earth, and the second by its Diurnal rotation.

What are their magnitudes? What is their average distance from the sun? What is the time of their annual revolution? When were they discovered?

What apparent revolutions have the heavenly bodies collectively? How are these caused?

The heavenly bodies rise in the east and set in the west, once every 24 hours, in consequence of the rotation of the earth on its axis.

The planets *individually* have two apparent motions: viz., Direct and Retrograde.

A planet's motion is said to be Direct, when it appears to move from west to east, according to the order of the Signs.

A planet's motion is said to be Retrograde, when it appears to move backward, from east to west, or contrary to the order of the Signs.

When a planet appears to remain for some time, in the same point of the heavens, it is said to be Stationary.

These appearances are caused by the real motion of the Earth, together with that of the planet.

A planet appears to be Stationary, when it is moving directly towards, or from the Earth.

In the annexed diagram, supposing the earth to be at rest at E, when Venus moves from V to V', she appears to move from D to B, westward or contrary to the order of the signs; and when she passes from V' back again to V, she appears to move from B to D, or according to the order of the signs. But instead of being at rest, the earth is moving the same way. Suppose, therefore, she moves from E to E', while Venus is moving from V to V'; when Venus arrives at V', she will have appeared to pass from D to B', in the same direction as before, only not so far by the arc B B'. If the earth moves from E to E', while Venus is moving from V' to V, Uranus will appear to pass from B to D', in the same direction as when the earth was at rest, only farther by the arc D D'. The earth's motion, therefore, does not affect the apparent direction of an inferior planet's motion, but makes it slower as it passes through its inferior, and quicker as it passes through its superior conjunction. The apparent motion

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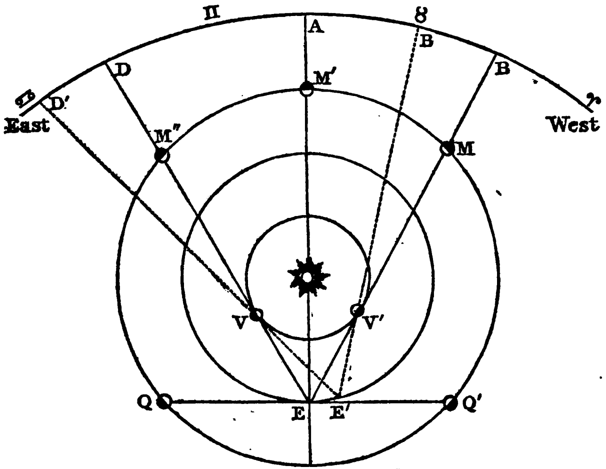
Why do the heavenly bodies rise and set? What apparent motions have the planets individually? When is a planet's motion said to be direct? When is it said to be retrograde? When is a planet said to be stationary? By what are these appearances caused? When does a planet appear to be stationary?

of an inferior planet is therefore retrograde, while passing through its inferior, and direct while passing through its superior conjunction. Were the earth at rest, the planet would appear stationary at the points of greatest elongation, viz., at V and V′; but, owing to the earth's motion, this happens at a point between inferior conjunction and greatest elongation.

The apparent motions of a superior planet, are somewhat different from those of an inferior planet, because the earth is moving faster than the planet; but they may be explained in a similar manner. In passing through its superior conjunction, the motion of a superior planet is direct, because the combined effect of the earth's and planet's own motions, is to give it such a motion; but in opposition, the earth moving more rapidly, passes the planet, and gives it an apparent retrograde motion. Thus, when Mars is moving from M to M′, were the earth at rest, at E, it would appear to move from B to A, while the effect of the earth's motion is only to give it a greater apparent motion in the same direction. From Q to Q′, it is direct or retrograde, according as the effect of the earth's motion is greater or less than that of the planet. When these effects are the same, the planet appears stationary, which happens between quadrature and opposition.

Fig. 26.



CHAPTER XVII.

ECLIPSES.

An Eclipse is the concealment of a heavenly body, by some opaque body, intercepting the Sun's rays.

The principal Eclipses, are the Solar and Lunar.

A Solar Eclipse, is an eclipse of the Sun.

It is caused by the Moon's passing between the Earth and the Sun, and concealing the Sun from our view.

A Lunar Eclipse, is an eclipse of the Moon.

It is caused by the Moon's passing through the Earth's shadow.

A Solar Eclipse can happen only at New Moon; a Lunar Eclipse, at Full Moon.

Eclipses are of two kinds, Total and Partial.

A Total Eclipse is one, in which the disc is entirely concealed.

A Partial Eclipse is one, in which only a part of the disc is concealed.

An Annular Eclipse is an eclipse of the Sun, in which a bright ring appears around the dark body of the Moon.

It happens when the Moon is too far from the Earth, to conceal the whole of the Sun's disc.

What is an eclipse? What are the principal eclipses? What is a solar eclipse? How is it caused? What is a lunar eclipse? How is it caused? When can these eclipses happen? Of how many kinds are eclipses? What is a total eclipse? What is a partial eclipse? What is an annular eclipse? When does it happen?

An eclipse does not happen at every new and full Moon; because the Moon is not at, or near its node.

The Ecliptic Limit, is the distance from the node, within which an eclipse can occur.

The Solar Ecliptic Limit, extends 17 degrees, each side of the node.

The Lunar Ecliptic Limit, extends 12 degrees, each side of the node.

The Penumbra, is the faint shadow caused by a partial interception of the Sun's rays.

The Earth's shadow, varies in length, as the distance of the Earth from the Sun.

At the Earth's mean distance from the Sun, it is 860,000 miles in length.

Its breadth, where it eclipses the Moon, is about three times the Moon's diameter.

The shadow of the Moon, when at its mean distance from the Sun and Earth, nearly reaches the surface of the Earth; and never exceeds 170 miles in diameter, where it intersects the Earth.

The greatest number of eclipses that can happen in a year, is *seven;* five of the Sun, and two of the Moon.

The least number is *two*, which must both be of the Sun.

Lunar eclipses are more frequent, at any particular place, than those of the Sun:

Why does not an eclipse happen at every new and full moon? What is the ecliptic limit? How many degrees does the solar ecliptic limit extend? How many does the lunar ecliptic limit? What is the penumbra? What is the length of the earth's shadow? What is its breadth, where it eclipses the moon? What is the length of the moon's shadow? What is its diameter, where it intersects the earth? What is the greatest number of eclipses, that can happen in a year? What is the least number?

Because they are visible to an entire hemisphere; while those of the Sun, are visible only to that part covered by the Moon's shadow.

Eclipses sometimes take place, of Jupiter's Satellites.

Occultation is the concealment of a planet or star, by the interposition of the Moon.

In the annexed diagram, M represents the position of the Moon at the time of a total eclipse of the Sun; and *m* its position at the time of a total eclipse of the Moon; *p* and *p*, represent the Penumbra of the Moon; and P and P, that of the earth.

Fig. 27.

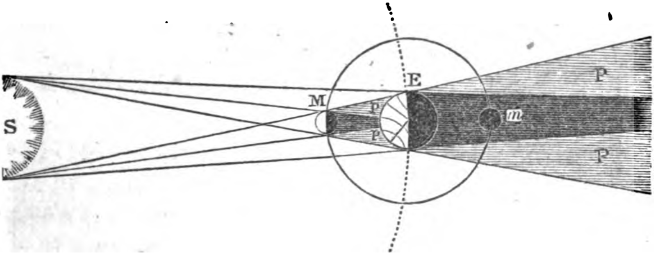
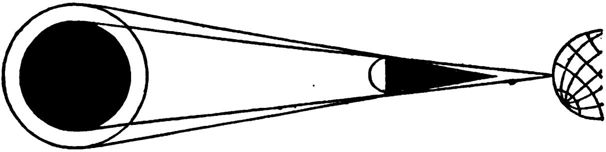


Figure 28 represents an annular eclipse of the Sun; in which, it will be perceived, the shadow of the Moon does not reach the surface of the Earth.

Fig. 28.



Why are lunar eclipses more frequent at any particular place? What other eclipses sometimes take place? What is occultation?

CHAPTER XVIII.

TIDES.

Tides are the alternate rising and falling of the water, in Oceans, Rivers, etc.

They are divided into Flood and Ebb, and Spring and Neap Tides.

Flood Tide is the rising of the water.

When it is at its highest point, it is called High Water.

Ebb Tide is the falling of the water.

Flood and Ebb Tide happen twice every 25 hours.

Spring Tide is the greatest flood and ebb tide.

Neap Tide is the least flood and ebb tide.

Tides are occasioned by the attraction of the Sun and Moon, acting unequally upon opposite sides of the Earth.

The *disturbing* influence of the Moon, is three times as great as that of the Sun; because it is so much nearer the Earth.

The attraction of the Sun and Moon always produces similar tides, on *opposite* sides of the Earth, at the same time.

Spring Tide is caused by the Sun and Moon's being on the same or opposite sides of the Earth, and thus acting together.

What are tides? How are they divided? What is flood tide? At its highest point, what is it called? What is ebb tide? How often do flood and ebb tides happen? What is spring tide? What is neap tide? By what are tides caused? How much greater is the disturbing influence of the moon? Why? Where are similar tides produced? By what is spring tide caused?

It occurs at New and Full Moon, or a short time afterwards.

Neap Tide is caused, when the Sun and Moon are in quadrature, by their attracting forces counteracting each other.

It occurs twice in each lunar month, when the Moon is in her first and last quarters.

Primitive Tides, are those which are directly occasioned by the Sun and Moon; such as those which take place in the ocean.

Derivative Tides, are those which take place in narrow bays, inlets, etc., owing to the primitive tides.

The highest tides, occur in narrow bays, and arms of the sea, running up into the land.

Lakes have no perceptible tides.

The highest tides in the world, take place in the Bay of Fundy, where they rise about 70 feet.

The average height, for the whole globe, is 2½ feet.

The tide rises about 50 minutes later, each successive day.

This is caused by the Moon's advance in its orbit, so that the same place on the Earth's surface, does not come again under the Moon, until 50 minutes later.

The tide does not rise, until several hours after the Moon has passed the meridian.

When does it occur? When is neap tide produced, and by what? How often does it occur? What are primitive tides? What are derivative tides? Where do the highest tides occur? Have lakes any tides? Where do the highest tides in the world occur? How high do they rise at that place? What is the average height for the whole globe? Does the tide rise at the same hour every day? Why does it rise later? Does the tide rise, when the moon is on the meridian?

This is caused by the rotation of the Earth on its axis, and by the inertia of the water.

By inertia is meant, the resistance which all matter makes to be set in motion, when at rest, or to be stopped, when in motion. In consequence of this property of matter, the waters do not immediately yield to the action of the sun and moon. The tide is also retarded by the friction of the waters on the bottom of the ocean.

In the open sea, where the tide is least obstructed, it is about two or three hours behind the Moon. In New York, about 8½ hours.

In the northern hemisphere, the highest tides occur, during the day in summer, and during the night in winter.

Fig. 29.

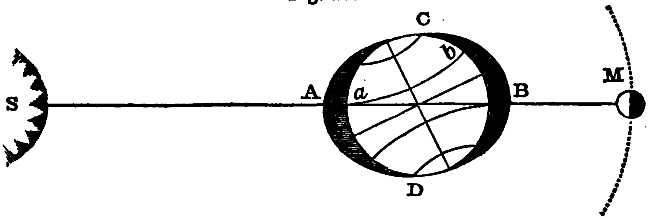


Figure 29, represents Spring Tide during summer, in the northern hemisphere. The greatest elevation of the water, takes place at A and B, and the greatest ebb tide, at C and D, 90 degrees distant from those points. The Sun, attracting the water at A, more than any other part of the earth, and that at B, less than any other part, diminishes the gravity of the earth, at those two points; in consequence of this, the centrifugal force, gives the water there a tendency to fly off from the earth; and it rises at both places at the same time. The Moon being in a line with the Sun, whether in opposition or conjunction, raises a tide at the same points; so that both their forces are united, and a high tide is the result. A comparison of the height of the water, at *a* and *b*, will explain, why the tide is highest, in the northern hemisphere, during the day, and lowest during the night.

What is this caused by? How much behind the moon is the tide in the open sea? How much in New York? When do the highest tides occur in the northern hemisphere?

Fig. 30.

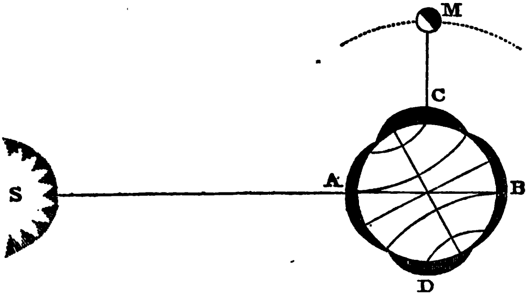


Figure 30, represents Neap Tide. The effect of the Moon at C and D, and the Sun at A and B, is to equalize the water all over the globe, and cause the least flood and the least ebb tides. In conjunction and opposition, as in Figure 29, the tide raised by the Sun and Moon, is equal to the *sum* of their separate tides, in quadrature,—as in Figure 30, the tide raised is equal to the *difference* of their separate tides.

The pupil must remember, in inspecting these diagrams, that the effects of the Sun and Moon, are not, by any means, so great as represented. The protuberances are exaggerated, for the purpose of illustration; but, in fact, they are only between two and three feet in 8000 miles; so small as to make no perceptible change in the figure of the earth.

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CHAPTER XIX.

PARALLAX.

PARALLAX is the change of place which a body appears to undergo, when viewed from different points.

The Apparent Place of a heavenly body, is that in which it seems to be, when viewed from the Earth's surface.

What is parallax? What is the apparent place of a heavenly body?

The True Place, is that in which it would seem to be, if viewed from the centre of the Earth.

The Diurnal Parallax of a body, is the difference between its true and apparent place.

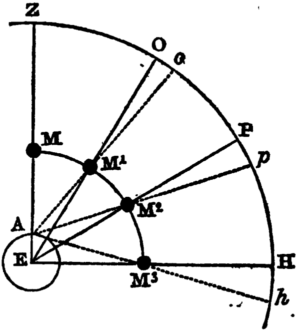
Horizontal Parallax, is the diurnal parallax of a body when in the horizon.

The Horizontal Parallax of the Sun, is about eight seconds.

Diurnal Parallax is greatest at the horizon, and diminishes towards the zenith, where it is nothing.

The effect of Parallax, is to diminish the altitude of a body.

Fig. 31.



In Figure 31, let Z H represent a portion of the sphere of the heavens; M, M^1, etc., the moon at different altitudes; and E the earth. To a spectator at A, when the moon is at M^3, or in the horizon, it appears at *h*, but if viewed from E, it would appear at H; *h* is therefore its apparent, and H its true place; and the difference H *h* is the diurnal parallax. As the body is in the horizon, it is also the horizontal parallax. P *p* and O *o*, represent each the diurnal parallax, for its respective altitude. At M, the body being in the zenith, is in a line with the spectator, and centre of the earth; consequently there is no parallax, at that point. In the horizon, the parallax, is evidently the greatest. H *h*, is called the *parallactic arc*, and the angle H M^3 *h*, the *angle of parallax*. The same terms are applied to P *p* and O *o*, and their corresponding angles. That parallax diminishes the altitude of a body, will be evident, from an inspection of the diagram.

What is the true place? What is diurnal parallax? What is horizontal parallax? How great is the horizontal parallax of the sun? Where is the diurnal parallax greatest? Where is it nothing? What is the effect of parallax?

Annual Parallax is the apparent change of place of a Star, when viewed from opposite points of the Earth's orbit.

Only a very few of the Stars, have any annual parallax, on account of their immense distance from the Earth.

The parallax of the nearest, is less than one second.

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CHAPTER XX.

REFRACTION AND TWILIGHT.

REFRACTION, in astronomy, is the change of direction which the rays of light undergo, in passing through the Earth's atmosphere.

The Earth's atmosphere is not of a uniform density, but becomes less and less dense as we proceed from the surface.

The rays of light are refracted, only when they strike the atmosphere *obliquely*.

Refraction is therefore greatest, when the body is in the horizon, and nothing, when it is in the zenith.

The effect of Refraction, is to *increase* the altitude of a body, or *elevate* it above the horizon.

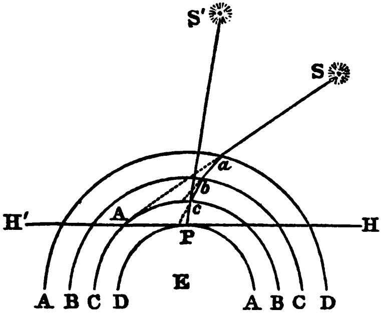
What is annual parallax? How many stars have any? How great is the parallax of the nearest?

What is refraction? Is the earth's atmosphere of uniform density? When are the rays of light refracted? When is refraction greatest? When is it nothing? What is the effect of refraction?

At the horizon it amounts to about 33 minutes.

In consequence of Refraction, therefore, the Sun appears above the horizon, when it is actually below it; and the day is lengthened from six to ten minutes.

Fig. 32.



In the annexed diagram, let E represent the earth, and A B C D, portions or strata of its atmosphere, of different densities, P the place of observation, and H′ P H, its horizon. Suppose a ray of light from the star S, strikes the atmosphere at *a*; on account of its density, instead of proceeding in a straight line, in the direction S A, it describes *a b*, *b c* and *c* P, and reaches the spectator at P. Now because we always see an object, in the direction, in which the ray of light strikes the eye, the star will be seen at S′ instead of S. The difference is the refraction. As the atmosphere does not consist of distinct strata, as represented, but diminishes *uniformly* in density from the surface of the earth, the broken line *a b c* P is in reality a curve, and the line S′ P a tangent to it, at the point P.

Twilight is that faint light, seen before the rising, and after the setting of the Sun.

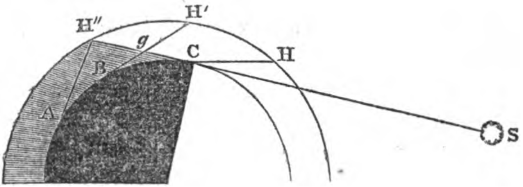
It is caused by the atmosphere's reflecting the light of the Sun.

Twilight commences and ends, when the Sun is 18 degrees below the horizon.

Twilight is shortest at the Equator, and longest at the Poles.

How great is it at the horizon? What is the effect of refraction on the sun when rising and setting? What on the length of the day? What is twilight? By what is it caused? When does twilight commence and end? Where is it shortest, and where longest?

Fig. 33.



Let A B C represent three places on the Earth, and A H″, B H′, C H, their horizons respectively. Let S represent the Sun, a little below the horizon, whose rays pass through the atmosphere, in the direction S H″. It will be seen that the sun is below the horizon of each place; but at C, there is twilight, because the portion of the atmosphere, H″C H, is illuminated, and by it the light reflected on the place below; at B, a smaller portion, H″ *g* H, receives the rays of the sun; while at A, the light entirely disappears.

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CHAPTER XXI.

TIME.

Time is duration, as measured by the motions of the heavenly bodies.

The Apparent motions of the Sun and Moon, afford standards for measuring time.

A Day is either Solar, Sidereal, or Civil.

A Solar day, is the period which elapses between the Sun's leaving the meridian of any place, until it arrives at it again.

The Solar days, are of unequal length.

What is time? What afford standards for measuring it? How many kinds of days are there? What is a solar day? Are the solar days equal?

A Sidereal day, is the time which elapses between a *star's* leaving the meridian of any place, until it returns to it again.

The Solar day, is about four minutes longer than the sidereal day.

This difference is caused by the Earth's motion eastward in its orbit.

Apparent time, is that reckoned by the apparent revolutions of the Sun.

Mean time, is that reckoned by the average length of the solar days throughout the year.

Clocks are constructed, to show Mean time.

The Equation of Time, is the difference between Mean and Apparent time; or the difference between time, as shown by the Sun, and that shown by a well-regulated clock.

The Equation of Time, is greatest about the 3d of November, when it is about 16¼ minutes, and is to be subtracted.

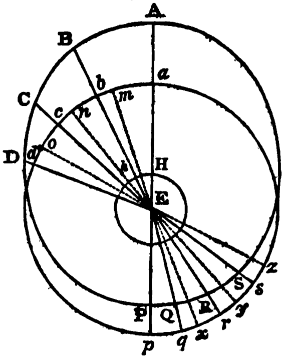
That is to say, when it is noon by the sun, it wants 16¼ minutes of it, by a well-regulated clock.

It is *nothing*, four times during the year; namely, April 15th, June 15th, September 1st, and December 22d.

The Equation of Time, is caused by the obliquity of the Ecliptic, and the variable motion of the Earth, in its orbit.

What is a sidereal day? How much longer is the solar than the sidereal day? What is the cause of the difference? What is apparent time? What is mean time? Which do clocks show? What is the equation of time? When is the equation of time greatest? How great is it at that time? When is it nothing? By what is it caused?

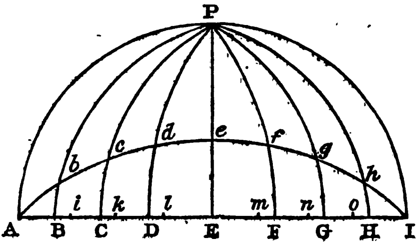
Fig. 34.



In Figure 34, let E represent the Earth, A B C P Q R the Sun's apparent orbit; A being the aphelion, and P the perihelion. Were the Sun at rest at A. the place H, on the surface of the Earth, would, as it rotates on its axis, return to the Sun in exactly the time of one rotation, and the solar day would be no longer than the sidereal day; but, during one rotation, suppose the Sun to move, apparently, from A to B; then the Earth will have to move more than one rotation, by the arc H *h*, in order to overtake the Sun. This causes the solar day to exceed the sidereal day, by an average difference of four minutes. But, as the Sun is not uniform in his motions, this is not always the difference. To show this, draw a circle, *a m n o*, etc., and let each of the equal arcs, *am*, *mn*, *no*, represent a space which the Sun would move over, during one rotation of the Earth, if he moved uniformly in a circle, and kept time with the clock. As at A, the Sun's motion is the most rapid, the divisions, as marked by the Sun, will be greater than those marked by the clock; and the place H, will arrive at *m*, before it reaches the Sun at B, by the arc *m b;* this is the equation of time: and, therefore, *while the Sun moves faster than the clock, it will be noon by the clock before it is so by the Sun;* that is, the time shown by the Sun, will be slower than that shown by the clock, and the equation of time must be added. This, it will be seen, is the case from A to P. From P to A, the reverse is the case; the Sun moves slower than the clock, and the equation is to be subtracted. This fact may be expressed briefly, by saying, that the equation of time must be added, as the Sun moves from aphelion to perihelion, and subtracted, as it moves from perihelion to aphelion; while at both those points, it vanishes.

These, it must be remembered, are the effects of only one of the causes which produce the equation of time, viz. the unequal motion of the earth in its orbit. The other cause may be illustrated as follows:

Fig. 35.



Let the figure A P I represent the Northern Hemisphere; A E I the Equinoctial; and A *e* I the Ecliptic. Let the ecliptic be divided into equal portions, at the points *b c d*, etc., and the equinoctial at *i k l*, etc. Draw meridians through *b c d*, etc., cutting the equinoctial in B C D, etc. A *b*, *b c*, *c d*, etc., will then represent arcs of longitude, and A B, B C, C D, etc., arcs of right ascension, passed over by the Sun in equal periods of time, say from day to day.

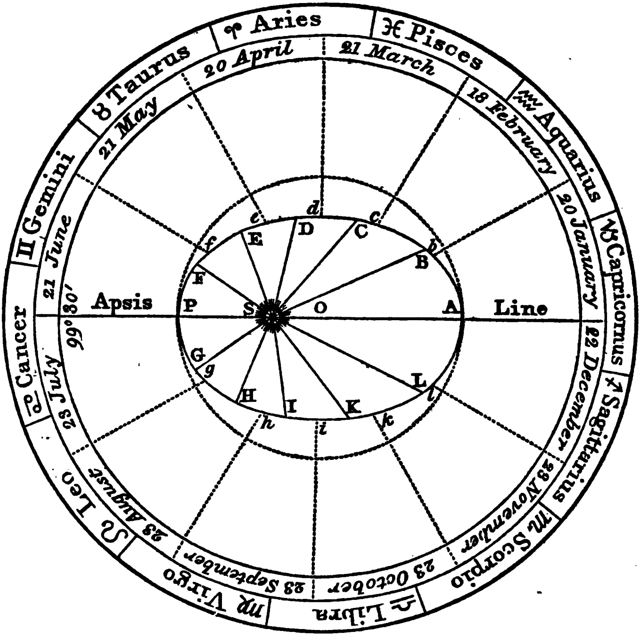
An inspection of the diagram, will show that these arcs do not correspond; but that, while the arcs of the ecliptic are equal to each other, those of the equinoctial are unequal, being shortest at the equinoctial points, A and I, and longest at the solstitial colure E, where the two circles are nearly parallel, and the divisions coincide. But differences of apparent time, are reckoned on the equinoctial, and are therefore unequal, being represented by the unequal arcs A B, B C, C D, etc., whereas the equal divisions A *i*, *i k*, *k l*, etc., represent divisions of mean time, as shown by the clock, and thus the difference between these is the equation of time. Thus, when the Sun passes from A to *b*, the earth has only to move over A B, to overtake him, whereas, if he kept time with the clock, it would have to move over A *i*, a greater distance by B *i*. The Sun, therefore, comes to the meridian before it is noon by the clock, and is therefore faster—so that the equation must be subtracted. This is the case from A to *e*, but from *e* to I, the Sun is slower than the clock, and the equation is to be added. In the third quarter of the ecliptic, it is again to be subtracted, and in the fourth, added. This is expressed, by saying, that the Sun is faster than the clock, from Aries to Cancer, slower from Cancer to Libra, faster from Libra to Capricorn, and slower from Capricorn to Aries; while they agree at all those four points.

The equation of time, being the result of both these causes acting together, is greatest only when their effects are similar, and nothing only when they balance each other. This takes place at the times stated in the text. The following shows the appropriate sign of the equation, from both these causes, for each month,—the sign of the first cause being placed before the other:— January + + February + + March + + April + — May + — June + — July — + August — + September — + October — — November — — December — —

These signs are true for the whole, or greater part of each month; while, for a few days of some, they must be altered. They may be easily verified by the annexed diagram (Figure 36), in connection with Figure 35.

As the Earth (Figure 36) is moving in one part of the ecliptic, the sun appears to move in the other; so that when the Earth is in the sign Aries, the Sun appears in the opposite sign Libra. The apparent velocity of the Sun, corresponds with the real velocity of the Earth, at the same time, except that, as to place, it is reversed. Thus, when the Earth is moving, with its greatest velocity, through the perihelion, the Sun appears to move, with the same velocity, through the aphelion. The annexed diagram, representing the apparent places of the Sun alone, has been drawn in accordance with its motions. Let the line A P represent the apsis line of the Earth's orbit; A being the aphelion and P the perihelion, the longitude of the latter being about 99½ degrees. Let also S rep-

Fig. 36.



resent the *real* place of the Sun, and O the centre of the Orbit. A B C D, etc., will then represent the *apparent* places of the Sun, for the corresponding months, and A *b c d*, etc., its mean places, for the same months. The spaces A B, B C, C D, etc., indicate unequal portions of apparent time, and A *b*, *b c*, *c d*, etc., equal portions of mean time, as kept by the clock. It will be seen that these do not agree; but that, from A to B, the sun moves faster than the clock by B *b*; and that, as it moves towards P, this difference increases, until at P, they coincide, and the equation vanishes. In the other half of the ecliptic, the same appearances are presented, except that the Sun keeps behind the clock, until at arrives at A, when the equation again vanishes. From this, it will be easily understood, why this cause, acting alone, would make the Sun arrive at the meridian *after* noon, as shown by the clock, from January to July, and *before* noon, from July to January.

CHAPTER XXII.

PRECESSION, ETC.

The Precession of the Equinoxes, is a gradual falling back of the equinoctial points, from *east* to *west*.

The amount of Precession, is fifty seconds every year.

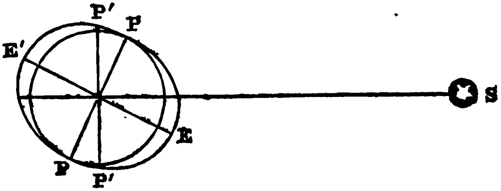
The Equinoxes make a complete revolution on the Ecliptic, in about 26,000 years.

The motion of the Equinoxes, causes the Pole of the Equinoctial to revolve around the pole of the Ecliptic.

In about 13,000 years, the Earth's axis, instead of pointing to the North Star, as at present, will point 47 degrees from it.

The Precession of the Equinoxes, is caused by the attraction of the Sun and Moon, acting upon the excess of matter at the Equator.

Fig. 37.



Thus (Figure 37), the attraction of the Sun, acts obliquely on the excess of matter, at E and E', and tends to draw it, towards the plane of the ecliptic. Were the Earth at rest, the effect of this would be, to shift the position of the

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What is the precession of the equinoxes? What is its amount? In what time do the equinoxes complete a revolution? What does this motion cause? In 13,000 years, where will the axis point? By what is precession caused?

Earth, drawing the equator E E′ to the ecliptic, and finally, causing the two circles to coincide. But, in consequence of the rotation of the Earth on its axis, the effect is merely to cause the equinoctial, apparently, to slide around, on the ecliptic, the two circles remaining at the same inclination; and the pole P, to revolve around the pole P′, as the peg of a top moves round, when its motion is becoming spent.

The Tropical Year, is the time which elapses from the Sun's leaving one of the equinoxes, until it arrives at the same again.

The Sidereal Year, is the time which elapses from the Sun's leaving a star, till it returns to the same again.

On account of the Precession of the Equinoxes, the Tropical year is about twenty minutes shorter than the Sidereal year.

This will be evident, from an inspection of Figure 36. For, suppose the Sun to be at D, while moving towards P; and that, during a complete revolution, the point D moves in an opposite direction to *d*; the Sun will return to D sooner than otherwise, by the distance D *d*.

The Line of Apsides of the Earth's orbit, has a slow motion, from west to east; completing a revolution, in about 100,000 years.

The Annual motion, is about twelve seconds.

The Longitude of the Perihelion, increases annually about sixty-two seconds.

Thus, the line P A (Figure 36), moves round, in the order of the signs, twelve seconds every year; but, as the first point of Aries, on account of the precession of the equinoxes, moves in an opposite direction, and longitude is reckoned from this point, twelve seconds added to the amount of precession, will give the annual change of the perihelion. This point is now, in about the tenth degree of Cancer. In the year 1248, it was exactly at the summer solstice; and about 5500 years ago, at the first point of Aries.

What is the tropical year? What is the sidereal year? What is the difference between them? What motion has the line of apsides? How great is the annual motion? How much does the longitude of the perihelion increase annually?

CHAPTER XXIII.

COMETS.

Comets are bodies which revolve around the Sun, in very eccentric orbits; and are generally accompanied by a long train of light.

A Comet generally consists of three parts; the Nucleus, the Envelope or Coma, and the Tail.

The Nucleus is the bright spot, seen in the centre of the comet.

The Envelope is the hazy or nebulous substance, which surrounds it.

The Tail is the train of light, accompanying it.

The exact number of comets belonging to the Solar System, is not known; but more than 500 have been observed, since the Christian era.

The Elements* of only 130 of these, have been calculated.

Comets revolve, both in an eastward and a westward direction; and their orbits are situated, at every inclination to the ecliptic.

Comets are supposed to be collections of gaseous matter; as their density is much less than that of the planets.

What are comets? Of how many parts does a comet consist? What is the nucleus? What is the envelope? What is the tail? How many comets are there belonging to the solar system? Of how many have the elements been calculated? How do comets revolve? What are comets supposed to be?

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* By the *elements* of a planet or comet, are meant the figure, dimensions, and position of its orbit.

The Tail of a comet, is generally on the side *from* the Sun, and is of a bent or curved form.

Some Comets are destitute of any tail; and others have more than one.

The Comet of 1744, had six tails, spread out in the form of a fan.

The Velocity of a comet, like that of the planets, increases as it approaches the Sun.

The Comet of 1680, moved 880,000 miles an hour.

The Time which a Comet takes, to revolve around the Sun, is not always the same, at different times.

This is occasioned, by the disturbing influence of the planets.

Comets are known to consist of only a small quantity of matter, by their not disturbing the planets which they approach, but being very much disturbed by them.

The Tails of some comets, extend an immense distance in the heavens.

The Comet of 1680, had a tail extending about 120 *millions* of miles.

On which side is the tail? Have all comets tails? What is said of the comet of 1744? When does the velocity of a comet increase? How great was the velocity of that of 1680? Does a comet revolve around the sun always in the same time? Why not? How are comets known to consist of a small quantity of matter? How far do their tails extend? How far did that of 1680?

CHAPTER XXIV.

THE FIXED STARS.

The Fixed Stars are those bodies which always appear, in the same relative situations.

Fixed Stars are supposed to be luminous bodies; because, if they borrowed their light from any other luminous body, that body would also be visible.

They are believed to be Suns, belonging to systems of planets, like the Solar System.

They are of different magnitudes; and some have been calculated to be much larger than the Sun.

The Stars have no *disc*, presenting only the appearance of *luminous points*.

The distance of the nearest fixed star, (*Alpha Centauri*,) has been calculated to be, about twenty trillions of miles from the Sun, or about 200,000 times as far as the Earth.

The distance of the next nearest, (61 *Cygni*,) is supposed to be three times as far as *Alpha Centauri*.

From the latter, light, travelling at the rate of 192,000 miles in a second, would require more than *nine years* to reach the Earth.

From the Pole Star, light requires more than *twenty years* to reach the Earth.

What are the fixed stars? Why are they supposed to be luminous? What are they believed to be? Are they of the same size? Have they any disc? What is the distance of the nearest? What is that of the next? In what time would light pass from the latter to us? In what time from the pole star?

The distances of only *seven* of the Fixed Stars, have been ascertained, with any degree of precision.

It is impossible to estimate the *number* of the Fixed Stars; they doubtless amount to *millions of millions.*

Variable Stars, are those which do not always shine with the same brightness.

This is accounted for by supposing that they revolve on axes, and present to us sides differing in brightness; or that their light is obscured by the interposition of planets, revolving around them.

Temporary Stars, are those which have suddenly appeared in the heavens, and, after a certain time, as suddenly disappeared.

Ten new stars appeared, and thirteen disappeared during the last century.

No satisfactory theory has been advanced to account for these wonderful phenomena. The fact, that some stars have suddenly shone out, with such an extraordinary degree of brilliancy, as to be seen at mid-day, and, after a short time, have faded away and disappeared, would seem to indicate some extensive conflagration on their surface, or their entire destruction by fire. This is, accordingly, the opinion of many; while others suppose that these bodies may be revolving in ellipses, and, at one time, approach so near as to be visible in the day time; while at others, they recede to the farthest points of their orbits, and thus entirely vanish from our view.

Nebulous Stars, are those which are surrounded by a hazy appearance, like the nucleus of a comet.

Multiple Stars, are those which, on being viewed with a telescope, appear to consist of two or more Stars.

Double Stars, are those which are separated by the telescope into two Stars.

Several stars appear double, although at immense distances from each other,

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Of how many stars, have the distances been ascertained? What is the number of the stars? What are variable stars? What are temporary stars? How many appeared and disappeared during the last century? What are nebulous stars? What are multiple stars? What are double stars?

on account of their being situated nearly in the line of vision; these are said to be *optically* double. Others are actually connected, and revolve one around the other; these are said to be *physically* double.

Binary Systems, are double stars, one of which revolves around the other;—or both revolve around their common centre of gravity.

Binary Systems sometimes exhibit Stars, of *different colors.*

Between *forty* and *fifty* have been discovered.

Their periods of revolution, vary from forty to sixteen hundred years.

The Galaxy or Milky Way, is a faint zone of light encompassing the heavens, and discovered, by the telescope, to consist of vast numbers of Stars.

A Cluster is a number of stars collected in a certain space.

Nebulæ are certain cloudy appearances, seen in the heavens; most of them supposed to consist of vast numbers of Stars.

They may be divided into two classes; viz., Resolvable, and Irresolvable.

Resolvable Nebulæ, are those which are supposed to consist of vast numbers of Stars, so far distant as to appear like spots of cloud.

Irresolvable Nebulæ, are those which the most powerful telescopes, have failed to resolve into Stars.

The latter are supposed to be luminous matter, condensing into solid bodies, like the Sun.

What are binary systems? What do they sometimes exhibit? How many have been discovered? What are their periods of revolution? What is the galaxy or milky way? What is a cluster? What are nebulæ? How many classes are there? What are resolvable nebulæ? What are irresolvable nebulæ? What are the latter supposed to be?

Nebulæ which resemble the disc of a planet, are called Planetary Nebulæ.

Those, which have the appearance of a Star, surrounded by luminous matter, are called Stellar Nebulæ.

The Galaxy, or Milky Way, is supposed to be a nebula, or cluster, of which the Sun is a member.

Its shape is supposed to resemble an *immènse wheel*, the Sun being situated comparatively near the centre.

All the Stars in this cluster, including the Sun, are believed to revolve around their common centre of gravity.

The Universe is supposed to consist of an *infinite number* of Clusters similar to that, of which the Sun is a member, and situated at immense distances from each other.

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CHAPTER XXV.

CONSTELLATIONS.

A **Constellation** is a number of Stars, included in a certain space.

There are ninety-three Constellations set down on most globes.

The Constellations are divided into three classes, viz., Northern, Southern, and Zodiacal.

What are planetary nebulæ? What are stellar nebulæ? What is the galaxy supposed to be? What is its shape? What revolution have the stars of this cluster? Of what does the universe consist?

What is a constellation? How many are there? Into how many and what classes are they divided?

The Northern Constellations, are those which lie north of the Zodiac.

The Southern Constellations, are those which lie south of the Zodiac.

The Zodiacal Constellations, are those which lie within the Zodiac.

The Northern are thirty-four in number, the Southern forty-seven, and the Zodiacal, twelve.

The names of the Constellations of the Zodiac, are the same as those of the Signs.

In consequence of the precession of the equinoxes, the Signs have fallen back of the Constellations, about thirty-one degrees.

They corresponded twenty-two centuries ago.

Stars are classified, according to their apparent size or brightness.

The brightest stars, are said to be of the first magnitude, and the least that are visible to the naked eye, are of the sixth.

Telescopic Stars, are those which can only be seen with a telescope.

What are the northern constellations? What are the southern? What are the zodiacal? What is the number of each? What are the names of the zodiacal? Do the signs and constellations correspond? When did they correspond? How are stars classified? How are the brightest stars distinguished? What are telescopic stars?

The following is a list of the Constellations, with the principal Stars in each. The figure after the Star denotes its magnitude.

THE ZODIACAL CONSTELLATIONS.

	NUMBER OF STARS.	NAMES OF THE PRINCIPAL STARS.
ARIES, *The Ram*,	66	Arietis 2.
TAURUS, *The Bull*,	141	Aldebaran 1, The Pleiades, The Hyades.
GEMINI, *The Twins*,	85	Castor 1, and Pollux 2.
CANCER, *The Crab*,	83	
LEO, *The Lion*,	95	Regulus 1.
VIRGO, *The Virgin*,	110	Spica Virginis 1, Vindemiatrix 2.
LIBRA, *The Balance*,	51	
SCORPIO, *The Scorpion*,	44	Antares 1.
SAGITTARIUS, *The Archer*,	69	
CAPRICORNUS, *The Goat*,	51	
AQUARIUS, *The Water-bearer*,	108	Scheat 3.
PISCES, *The Fishes*,	113	

THE NORTHERN CONSTELLATIONS.

	NUMBER OF STARS.	NAMES OF THE PRINCIPAL STARS.
ANDROMEDA,	66	Mirach 2, Almaach 2.
AQUILA, *The Eagle*, and ANTINOUS,	71	Atair 1.
ASTERION et CHARA or CANES VENATICI, *The Greyhounds*,	25	
AURIGA, *The Charioteer*,	66	Capella 1.
BOOTES,	54	Arcturus 1, Mirach 3.
CAMELOPARDALUS, *The Camelopard*,	58	
CASSIOPEIA,	55	Schedar 3.

	NUMBER OF STARS.	NAMES OF THE PRINCIPAL STARS.
CEPHEUS,	35	Alderamin 3.
COMA BERENICES, *Berenice's Hair*,	43	
COR CAROLI, *Charles's Heart*,	3	
CORONA BOREALIS, *The Northern Crown*,	21	Alphacca 2.
CYGNUS, *The Swan*,	81	Deneb 1.
DELPHINUS, *The Dolphin*,	18	
DRACO, *The Dragon*,	80	Rastaben 2.
EQUULUS, *The Little Horse*,	10	
HERCULES ET CERBERUS,	113	Ras Algethi 3.
LACERTA, *The Lizard*,	16	
LEO MINOR, *The Little Lion*,	53	
LYNX, *The Lynx*,	44	
LYRA, *The Harp*,	22	Vega 1.
MONS MÆNALUS, *The Mountain Mænalus*,	11	
MUSCA, *The Fly*,	6	
PEGASUS, *The Flying Horse*,	89	Markab 2, Scheat 2.
PERSEUS, ET CAPUT MEDUSÆ,	59	Algenib 2, Algol 2.
SAGITTA, *The Arrow*,	18	
SCUTUM SOBIESKI, *Sobieski's Shield*,	8	
SERPENS, *The Serpent*,	64	
SERPENTARIUS, *The Serpent-bearer*,	74	Ras Alhagus 2.
TAURUS PONIATOWSKI, *Poniatowski's Bull*,	7	
TRIANGULUM, *The Triangle*,	11	
TRIANGULUM MINUS, *The Little Triangle*,	5	
URSA MAJOR, *The Great Bear*,	87	Dubhe 1, Alioth 2, Benetnach 2.
URSA MINOR, *The Little Bear*,	24	Pole Star 2.
VULPECULA ET ANSER, *The Fox and the Goose*,	37	

THE SOUTHERN CONSTELLATIONS.

	NUMBER OF STARS.	NAMES OF THE PRINCIPAL STARS.
Apus or Avis Indica, *The Bird of Paradise,*	11	
Ara, *The Altar,*	9	
Argo Navis, *The Ship Argo,*	64	Canopus 1.
Brandenburgium Sceptrum, *The Sceptre of Brandenburgh,*	3	
Canis Major, *The Great Dog,*	31	Sirius 1.
Canis Minor, *The Little Dog,*	14	Procyon 1.
Centaurus, *The Centaur,*	35	
Cetus, *The Whale,*	97	Mencar 2.
Chamælion, *The Chamelion,*	10	
Circinus, *The Compasses,*	4	
Columba Noachi, *Noah's Dove,*	10	
Corona Australis, *The Southern Crown,*	12	
Corvus, *The Crow,*	9	Algorab 3.
Crater, *The Cup,*	31	Alkes 3.
Crux, *The Cross,*	6	
Doroda, or Xiphias, *The Sword-fish,*	7	
Equuleus Pictoreus, *The Painter's Easel,*	8	
Eridanus, *The River Po,*	84	Achernar 1.
Fornax Chemica, *The Furnace,*	14	
Grus, *The Crane,*	13	
Horologium, *The Clock,*	12	
Hydra, *The Water-Serpent,*	60	Cor Hydra 1.
Hydrus, *The Water-Snake,*	10	
Indus, *The Indian,*	12	
Lepus, *The Hare,*	19	
Lupus, *The Wolf,*	24	
Machina Pneumatica, *The Air-Pump,*	8	

	NUMBER OF STARS.	NAMES OF THE PRINCIPAL STARS.
Microscopium, *The Microscope*,	10	
Monoceros, *The Unicorn*,	31	
Mons Mensæ, *The Table-Mountain*,	30	
Musca Australis, *The Southern-Fly*,	4	
Norma Euclidis, *Euclid's Square*,	12	
Octans Hadleianus, *Hadley's Octant*,	43	
Officina Sculptoria, *The Sculptor's Shop*,	12	
Orion,	78	Betelguez 1, Rigel 1, Bellatrix 2.
Pavo, *The Peacock*,	14	
Phœnix,	13	
Piscis Notius, *The Southern Fish*,	24	Fomalhaut 1.
Piscis Volans, *The Flying Fish*,	8	
Praxiteles, or Cela Sculptoria, *The Engraver's Tools*,	16	
Pyxis Nautica, *The Mariner's Compass*,	4	
Reticulus Rhomboidalis, *The Rhomboidal Net*,	10	
Robur Caroli, *Charles's Oak*,	12	
Sextans, *The Sextant*,	41	
Telescopium, *The Telescope*,	9	
Toucan, *The American Goose*,	9	
Triangulum Australe, *The Southern Triangle*,	5	

TABLE OF PRINCIPAL STARS.

Achernar, in Eridanus, or the River Po.
Acubens, in the *claw* of Cancer.
Aldebaran, in the *eye* of Taurus.
Algol, in the *head* of Medusa.

Alioth, in the *tail* of Ursa Major.
Almaach, in the *foot* of Andromeda.
Alphacca, in the Northern Crown.
Alruccabar, the Pole Star, in Ursa Minor.
Antares, in the *heart* of Scorpio.
Arietis, in Aries.
Atair, in Aquila, the Eagle.
Arcturus, in Bootes.
Bellatrix, in the *west shoulder* of Orion.
Betelguez, in the *east shoulder* of Orion.
Canopus, the *bright star* in Argo.
Capella, the *bright star* in Capricorn.
Castor and **Pollux**, in the *head* of Gemini.
Cor Caroli, the *double star* in the Greyhounds.
Deneb, in the *tail* of Cygnus.
Fomalhaut, in the Southern Fish.
Hyades, a *cluster of stars* in Taurus.
Markab, in the *wing* of Pegasus.
Menkar, in the *jaw* of the Whale.
Mirach, in the *thigh* of Bootes.
Mirach, in the *girdle* of Andromeda.
Pleiades, a *cluster* in Taurus.
Procyon, in Canis Minor.
Rastaben, in the *head* of Draco.
Ras Algethi, in the *head* of Hercules.
Ras Alhagus, in Serpentarius.
Regulus, in the *heart* of Leo.
Rigel, in the *foot* of Orion.
Scheat, in Aquarius.
Schedar, in the *breast* of Cassiopeia.
Scheat, in the *thigh* of Pegasus.
Sirius, in Canis Major.
Spica Virginis, in the *sheaf* of Virgo.
Vega, in Lyra.
Vindemiatrix, in Virgo.

PART II.

THE ARTIFICIAL GLOBES.

CHAPTER I.

APPENDAGES TO THE GLOBES.

The Brazen Meridian is a circle of brass, which encompasses the artificial globe from pole to pole.

It is intended to represent, the Meridian of any place on the globe.

It is divided into degrees, on one semicircle, from the Equator towards the Poles; and on the other, from the Poles towards the Equator.

The Hour Circle is a small circle, described round the North Pole, with the hours of the day marked on it.

The Wooden Horizon is a circular plane, encompassing the artificial globe, to represent the Rational Horizon.

The Quadrant of Altitude, is a flexible strip of brass, graduated upwards from 0 to 90 degrees, and downwards from 0 to 18 degrees.

It is used to measure distances, on the artificial globe.

What is the brazen meridian? What does it represent? How is it divided? What is the hour circle? What is the wooden horizon? What is the quadrant of altitude? For what is it used?

The Mariner's Compass, is a representation of the horizon, and is divided into 32 equal parts, called points of the Compass.

The four cardinal or principal points of the horizon, are North, East, South, and West.

The Angle of Position, between two places, is an angle, formed at the zenith of one of the places, by the meridian of that place, and a vertical circle, passing through the other place.

It is reckoned on the wooden horizon.

Rhumbs are 32 divisions of the horizon, called the points of the compass.

A Rhumb Line is a line which a ship describes, while she sails on the same point of the compass, and cuts all the meridians, at the same angle.

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CHAPTER II.

PROBLEMS FOR THE TERRESTRIAL GLOBE.

PROBLEM I.

To find the latitude and longitude of any given place.

RULE.—Bring the given place to the graduated side of the brazen meridian, which is numbered from the equator towards the poles; and the degree of the merid-

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What is the mariner's compass? What are the cardinal points? What is the angle of position between any two places? On what is it reckoned? What are rhumbs? What is a rhumb line?

ian, over the place, will be the latitude; and the degree of the equator, under the meridian, will be the longitude.

On Wilson's Globes, there are two rows of figures above the equator. When the place lies on the east side of the meridian of London, the longitude is found on the upper line; and when it is on the west side, on the lower line.

EXAMPLES.

Find the latitude and longitude of the following places:

1.	New York,	*Answer*,	41°	N.	74°	W.
2.	Amsterdam,	“	52½°	N.	5°	E.
3.	Mobile,	“	31°	N.	88°	W.
4.	Louisville,	“	38½°	N.	86°	W.
5.	Columbus,	“	40°	N.	83°	W.
6.	Paris,	“	49°	N.	2½°	E.
7.	Rio Janeiro,	“	22°	S.	43°	W.
8.	Quito,	“	0		78°	W.
9.	Delhi, Asia,	“	28½°	N.	78°	E.
10.	Valparaiso,	“	33°	S.	71°	W.
11.	Stockholm,	“	59½°	N.	18°	E.
12.	Jeddo,	“	36°	N.	140°	E.
13.	Tobolsk,	“	58°	N.	68½°	E.
14.	Mexico,	“	19½°	N.	100°	W.
15.	Pekin,	“	40°	N.	116°	E.
16.	London,	“	51½°	N.	0	
17.	East Cape,	“	66½°	N.	170°	W.
18.	North Pole,	“	90°	N.	0	

19. Cape Horn.
20. Morocco.
21. Naples.
22. Calcutta.
23. Vienna.
24. Smyrna.
25. St. Petersburgh.
26. Madrid.
27. Lima.

PROBLEM II.

The latitude and longitude of a place being given, to find the place.

RULE.—Find the degree of longitude on the equator; bring it to the brazen meridian, and under the given degree of latitude, on the meridian, will be the place required.

EXAMPLES.

Find the places, whose latitude and longitude are as follows:

30°	N.	90°	W.	*Answer.*	New Orleans.
43°	N.	72°	W.	"	Concord.
23½°	N.	57°	E.	"	Muscat.
50°	N.	14°	E.	"	Prague.
40°	N.	75°	W.	"	Philadelphia.
39°	N.	84°	W.	"	Cincinnati.
0°		78°	W.	"	Quito.
39°	N.	77°	W.	"	Washington.
12°	S.	77°	W.	"	Lima.
46°	N.	6°	E.	"	Geneva.

PROBLEM III.

To find the difference of latitude or longitude between any two places.

RULE.—Find the latitude or longitude of both places; if alike, subtract them; if unlike, add them; and the sum, or difference, will be the answer required.

NOTE.—By *alike* is meant on the same side of the equator, or first meridian; by *unlike*, on different sides.

EXAMPLES.

Find the difference of latitude and longitude between the following places:

1. Alexandria and Amsterdam,	*Answer*,	Lat. 21°,	Long. 25°.
2. Athens and Berlin, . . .	"	Lat. 14°,	Long. 10°.
3. Rome and Washington, .	"	Lat. 3°,	Long. 89°.
4. Moscow and Botany Bay, .	"	Lat. 90°,	Long. 114°.
5. Stockholm and Rio Janeiro,	"	Lat. 81°,	Long. 61°.
6. Vienna and Lima, . . .	"	Lat. 60°,	Long. 93°.
7. Dublin and Valparaiso, . .	"	Lat. 86°,	Long. 65°.
8. North and South Pole, . .	"	Lat. 180°.	
9. New York and Pekin, . .			

PROBLEM IV.

To find all the places which have the same latitude as a given place.

RULE.—Bring the given place to the graduated side of the brazen meridian, and observe its latitude; turn the globe round, and all the places which pass under the same degree of the meridian, will be those required.

EXAMPLES.

Find the principal places which have the same, or nearly the same, latitude as—

1. INDIANAPOLIS.—*Answer.* Columbus, Philadelphia, Toledo, Minorca, Erzerum, Bucharia, Samarcand, Pekin.

2. BOSTON. . —*Answer.* Leon, Ajaccio, Rome, Derbent, Khiva, Matsmay, Cape Orford, Chicago, Detroit, Buffalo, Albany.

3. **Lima.** . . —*Answer.* St. Salvador, St. Felipe de Benguela, Lake Maravi, Comoro Isles, Cape Ambro, Gulf of Carpentaria, Navigator's Isles.

4. **Quito.** . . —*Answer.* Johannes Island, St. Thomas Island, Sumatra, Borneo, Celebes, Galipagos Isles.

5. **Havana.** . —*Answer.* Bahama Isles, Great Desert of Sahara, Assouan, Muscat, Gulf of Cutch, Canton, Formosa, Anson's Archipelago, Cape St. Lucas, Zacatecas.

6. North Cape.
7. Jeddo.
8. St. Petersburgh.
9. Constantinople.
10. Rio Janeiro.
11. Bombay.
12. London.
13. Lisbon.
14. Mexico.

PROBLEM V.

To find all those places which have the same longitude as any given place.

Rule.—Bring the given place to the graduated side of the brazen meridian, and all places under the meridian, from pole to pole, will be those required.

EXAMPLES.

Find all places having the same, or nearly the same, longitude as—

1. **Lima.** . . —*Answer.* Lancaster Sound, Hudson's Straits, East Maine, Kingston, Harrisburgh, Baltimore, Washington, Richmond, Cape Lookout, Eleuthera, Kingston in Jamaica, Popayan.

2. LONDON. . —*Answer.* Havre, Bordeaux, Valencia, Oran, Gulf of Guinea.

3. RIO JANEIRO. —*Answer.* Greenland, Cape Farewell, Maranham, Villa Rica.

4. NEW ORLEANS.—*Answer.* Barrow's Strait, Regent's Inlet, Wager River, Western part of Lake Superior, St. Louis, Yucatan, Guatimala, Galipagos Isles.

5. NAPLES. . —*Answer.* Spitzbergen, Luffoden Isles, Carlscrona, Trieste, Lipari Isles, Syracuse, Mourzouk, Lake Tchad, St. Salvador, Desert of Cimbebas.

6. Pekin.
7. Calcutta.
8. Quebec.
9. Cape Good Hope.
10. Dublin.
11. Stockholm.
12. Mexico.
13. Constantinople.
14. Cairo.

PROBLEM VI.

To find the distance between any two places on the globe.

RULE.—Lay the graduated edge of the quadrant of altitude* over both places, so that the division marked O, may be on one of them; and the number of degrees between them, reduced to miles, will be the distance required.

NOTE.—If geographic miles are required, multiply the degrees by 60; if statute miles, 69½.

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* The use of the quadrant of altitude, may be dispensed with in this problem, by laying a slip of paper over both places, and marking the distance between them; then placing it exactly over the equator, and the number of degrees included in the distance marked off, will be the answer in degrees. Then reduce as before.

EXAMPLES.

Find the direct distance, in geographic and statute miles, between the following places:

1. North Cape and Cape Matapan?—*Answer.* 2,100 Geographic miles; 2,432½ Statute miles.
2. Cape of Good Hope and Van Diemen's Land.
3. Cape Blanco, and Cape St. Roque.
4. St. Petersburgh and Astracan.
5. Calcutta and Pekin.
6. Paris and Vienna.
7. Savannah and New York.
8. New Orleans and Baltimore.
9. Cape Tamura and Cape Romania.
10. San Francisco and New York.

PROBLEM VII.

To find the Antoeci of any place.

RULE.—Bring the given place to the brazen meridian, and find its latitude; and under the meridian, at the same degree of latitude, in the opposite hemisphere, will be the place required.

EXAMPLES.

Find the Antoeci of the following places:

1. Cape Horn, . *Answer.* Central part of Labrador.
2. New York, . . " Northern part of Patagonia.
3. Jeddo.
4. Havana.
5. London.
6. Trinidad.
7. Pekin.
8. Savannah.
9. Lima.
10. Bombay.
11. Lassa.

PROBLEM VIII.

To find the Perioeci of any place.

Rule.—Bring the given place to the brazen meridian, note its latitude, and set the index to twelve; then turn the globe till the index points to the other twelve; and under the same degree of latitude, will be the place required.

EXAMPLES.

Find the Perioeci of the following places:

1. Bay of Bengal, ... *Answer.* Caribbean Sea.
2. London, ... " Fox Islands.
3. Naples.
4. Baltimore.
5. Cape Horn.
6. Mexico.
7. Paris.
8. Montreal.
9. Tobolsk.
10. Canton.
11. Cape Town.

PROBLEM IX.

To find the Antipodes of any place.

Rule.—Bring the given place to the brass meridian, note its latitude, and set the index to twelve; then turn the globe round until the index points to the other twelve; and under the same degree of latitude, in the opposite hemisphere, will be the place required.

EXAMPLES.

Find the Antipodes of the following places:

1. Quito, ... *Answer.* Sumatra.
2. Sandwich Islands, . . " Desert of Cimbebas.
3. New York.
4. London.
5. Cuba.
6. New Zealand.
7. Constantinople.
8. Lisbon.

PROBLEM X.

The hour of the day being given at any place, to find what time it is at any other place.

RULE 1.—Bring the place, at which the time is given, to the brazen meridian, set the index to the given hour, turn the globe till the other place comes to the meridian, and the index will show the hour required.

NOTE.—If the place, at which the time is required, be east of the given place, turn the globe westward; if west, turn it eastward. If it be east, the time is later; if west, earlier than that at the given place.

RULE 2.—Find the difference of longitude, between the two given places; multiply the degrees by four, and the product will be minutes of time; the minutes multiplied by four, will give seconds of time; reduce to hours, and it will give the difference of time. If the time required be earlier, subtract it, if later, add it, to the given time, and the result will be the answer required.

EXAMPLES.

1. When it is noon at New York, what o'clock is it at London?—*Answer.* 5 o'clock, P. M. (nearly.)

2. When it is 10 o'clock, A. M., at St. Petersburgh, what o'clock is it at Mexico?—*Answer.* 1 hour 20 min., A. M.

3. When it is midnight at New York, what o'clock is it, at

Calcutta,	Madrid,	Moscow,	New Orleans,
Lima,	Cape Horn,	Pekin,	Botany Bay?

4. When it is 8 o'clock, A. M., at Vienna, what time is it at

Washington,	Paris,	Constantinople,
Sandwich Islands,	Canton,	Archangel?

PROBLEM XI.

The hour of the day being given at any place, to find all the places at which it is any other given hour.

Rule.—Bring the given place to the brazen meridian, and set the index to the hour of that place; then turn the globe, till the index points to the other given hour; and all places under the meridian will be those required.

Note.—Turn the globe, as in the previous Problem.

EXAMPLES.

1. When it is 3 o'clock, A. M., in Philadelphia, at what places is it 8 o'clock, A. M.?—*Answer*. London, Havre, Bordeaux, and Valencia?

2. When it is midnight at Washington, at what places is it 7 o'clock, A. M.?

3. When it is noon at Paris, where is it midnight?

4. When it is 7 o'clock, P. M., at Lima, where is it noon?

5. When it is noon at New York, where is it 4 o'clock, P. M.?

6. Where is it 7 o'clock, A. M.?

7. When it is half-past 3 o'clock in the morning at Pekin, where is it half-past 1 in the afternoon?

PROBLEM XII.

To find the Sun's place in the Ecliptic, and longitude for any day in the year.

Rule.—Look for the given day of the month, on the wooden horizon, and the degree corresponding to it, in the circle of signs, will be the Sun's place in the ecliptic for that day: find it on the ecliptic; and the number of degrees, between it, and the first point of Aries, will be the Sun's longitude.

EXAMPLES.

Find the Sun's place, and longitude, for each of the following days:

1. June 21st. —*Answer.* Place, 1st degree of Cancer, Longitude, 90°.
2. February 22d.—*Answer.* Place, 4½ degree of Pisces, Longitude, 337½°.
3. December 22d.
4. July 4th.
5. March 21st.
6. January 1st.
7. November 20th.
8. April 18th.
9. September 18th.
10. May 15th.
11. August 25th.

PROBLEM XIII.

To find the Sun's declination for any day in the year.

RULE 1.—Find the Sun's place in the ecliptic, and bring it to the brazen meridian; and the degree of the meridian over it, will be the declination.

RULE 2.—Bring the analemma to the brazen meridian; and the degree of the meridian, over the given day of the month, will be the Sun's declination, for that day.

EXAMPLES.

Find the Sun's declination, for the following days:

1. April 15th. —*Answer.* 10 degrees North.
2. December 22d.— " 23½ degrees South.
3. August 15th.
4. January 28th.
5. March 21st.
6. September 1st.
7. June 21st.
8. February 1st.
9. October 20th.
10. September 23d.
11. November 1st.

PROBLEM XIV.

To find what places have a vertical Sun, on any particular day of the year.

Rule.—Find the Sun's declination, and note the degree on the brazen meridian; turn the globe around, and all places that pass under that degree, will be those required.

EXAMPLES.

What places have a vertical Sun on the following days?—

1. June 21st. —*Answer.* All places under the tropic of Cancer.
2. March 21st.— " All places under the equator.

3. December 25th.	5. April 1st.	7. October 10th.
4. July 4th.	6. January 20th.	8. May 1st.

PROBLEM XV.

To rectify the Globe for the latitude of a place, and Sun's place in the Ecliptic, for any given day.

Rule.—Elevate the north or south pole, according as the latitude of the place is north or south, a number of degrees corresponding to the latitude; find the Sun's place in the ecliptic, for the given day, bring it to the brazen meridian, and set the index to twelve.

PROBLEM XVI.

The day of the month being given, at any particular place, in the torrid or temperate zones, to find, at what time, the Sun rises and sets, and the length of the day and night.

Rule.—Rectify the globe for the latitude of the place,

&c., by Problem XV.; bring the Sun's place to the eastern edge of the horizon, and the index will show the hour of rising; subtract it from twelve, and the difference will be the time of setting.

Double the time of the Sun's setting, and it will give the length of the day; double the time of its rising, and it will give the length of the night.

EXAMPLES.

Find the time of the Sun's rising and setting, and the length of the day and night, at each of the following places, on the given day.

1. London, July 17th.—*Answer.* Sun rises at 4, and sets at 8, and the length of the day is 16 hours, that of the night 8.
2. New York, September 23d.
3. Paris, January 1st.
4. Washington, December 1st.
5. Vienna, March 25th.
6. Montreal, May 1st.
7. Stockholm, August 18th.
8. Lima, April 10th.
9. Naples, October 10th.

PROBLEM XVII.

To find the length of the longest and shortest days and nights, at any place, within the Torrid or Temperate zones.

RULE.—Find the length of the day and night at the given place, when the Sun is in the first degree of Cancer, if it be in north latitude, or when it is in the first degree of Capricorn, if the place be in south latitude, and it will give the length of the longest day. Subtract it from twenty-four, and the difference will be the shortest night. The shortest night at any place, is equal to its shortest day, and its longest night to its longest day.

EXAMPLES.

Find the length of the longest and shortest day at each of the following places:

1. New York.—*Answer.* Longest day, 14 hours, 56 minutes; shortest day, 9 hours, 4 minutes.
2. Quebec.
3. Buenos Ayres.
4. Canton.
5. London.
6. St. Petersburgh.
7. Archangel.
8. Quito.
9. Cape Horn.
10. Montreal.
11. Botany Bay.
12. New Orleans.
13. C. Good Hope.
14. Bombay.
15. Mexico.
16. Ceylon.

PROBLEM XVIII.

To find those places within the Torrid or Temperate zones, at which the longest day is of any particular length.

RULE.—If the places to be found, be in the northern hemisphere, bring the first degree of Cancer to the meridian, and set the index to twelve; then turn the globe, until the index has passed over half of the given time; raise or depress the north pole, until the first degree of Cancer is brought to the edge of the horizon, and the elevation of the north pole will show the latitude of the places required. If the places to be found be in the southern hemisphere, bring the first degree of Capricorn to the meridian, and raise the south pole instead of the north.

EXAMPLES.

1. At what places in the northern hemisphere, is the length of the longest day, 16½ hours?—*Answer.* All places in lat. 52° N.

2. At what places in the southern hemisphere, is the longest day, 19 hours?
3. At what places in north latitude is it 16 hours?
4. At what places in north latitude is it 20 hours?
5. At what places in north latitude is it 23 hours?
6. At what places in south latitude is it 18 hours?

PROBLEM XIX.

To find at what day of the month, constant day begins and ends, and its duration, at any place, within the North Frigid zone.

RULE.—Bring the given place to the meridian, and find its distance from the north pole; count the same number of degrees on the meridian from the equator, and mark the degree where the reckoning ends; then turn the globe; and the two points of the ecliptic which pass under that degree of the meridian, will be the Sun's place, at the beginning and end of constant day. Find the corresponding days, on the wooden horizon, and these will be the dates required. Calculate the number of days between these two dates, counting from the earlier to the later, and it will be the duration of constant day, at the given place.

EXAMPLES.

Find the beginning, end, and duration of constant day, at each of the following places:

1. North Cape.—*Answer.* Begins May 15th; ends July 20th; duration 75 days.
2. Northern extremity of Spitzbergen.
3. Cape Cevero, the northern extremity of Asia.

4. Kola, in the northern part of Lapland.
5. Lancaster Sound.
6. Winter Harbor, in Melville Island.
7. Disco Island.
8. North Pole.
9. Arctic Circle.

PROBLEM XX.

To find the Sun's meridian altitude, for any day in the year, at any given place.

RULE.—Rectify the globe for the latitude of the place, bring the Sun's place in the ecliptic to the meridian; and the number of degrees on the meridian, from the Sun's place to the horizon, will be the altitude required.

EXAMPLES.

Find the Sun's meridian altitude, at the following places, on the days given:

1. New York, June 21st.—*Answer.* 73 degrees (nearly.)
2. London, December 22d.
3. Washington, Sept. 23d.
4. Boston, March 21st.
5. Montreal, January 1st.
6. Lima, June 5th.
7. Quito, July 1st.
8. Paris, February 18th.
9. Malta, April 20th.
10. Rio Janeiro, Oct. 23d.
11. Bombay, May 21st.

PROBLEM XXI.

To find the Sun's amplitude, on any given day, at any place.

RULE.—Rectify the globe for the latitude of the place; bring the Sun's place, in the ecliptic, to the eastern edge of the horizon; and the number of degrees, from the

Sun's place to the eastern point of the horizon, will be the amplitude of the Sun at rising; bring the Sun's place to the western edge of the horizon, and the number of degrees to the west point, will be the amplitude of the Sun at setting.

EXAMPLES.

Find the Sun's amplitude, at the following places, on the days given:

1. London, 21st of June.—*Answer.* 39° 48′, North.
2. New York, 22d of December.
3. Philadelphia, 21st of May.
4. Cape of Good Hope, 10th of July.
5. Cape Town, 1st of April.
6. Washington, 18th of February.
7. Mexico, 23d of September.
8. Lima, 22d of December.
9. Quito, 21st of June.

PROBLEM XXII.

To find the Sun's altitude and azimuth, at any place, for any given day and hour.

RULE.—Rectify the globe for the latitude of the place, and screw the quadrant of altitude, over that latitude; find the Sun's place in the ecliptic, bring it to the meridian, and set the index to twelve; then, if the given time be before noon, turn the globe eastward; if afternoon, turn it westward, till the index points to the given hour; bring the graduated edge of the quadrant of altitude to coincide with the Sun's place; and the number of degrees, on the quadrant, from the Sun's place to the horizon, will be the altitude; and the number of degrees on the horizon, from the north or south points of the meridian, to the graduated edge of the quadrant, will be the Sun's azimuth.

EXAMPLES.

Find the Sun's altitude and azimuth, at the following places, at the given time:

1. New York, May 10th, 9 o'clock, A. M.—*Answer.* Altitude, 45½°; Azimuth, 107½° N., or 72½° S.
2. London, May 1st, 10 o'clock, A. M.—*Answer.* Altitude, 47°; Azimuth, 136° N., or 44° S.
3. Washington, June 21st, 8 o'clock, A. M.
4. Boston, December 5th, 3 o'clock, P. M.
5. Charleston, May 12th, 10 o'clock, A. M.
6. Madrid, January 20th, 4 o'clock, P. M.
7. Stockholm, July 1st, 6 o'clock, P. M.

CHAPTER III.

PROBLEMS FOR THE CELESTIAL GLOBE.

PROBLEM I.

To find the declination and right ascension of the Sun or a Star.

RULE.—Bring the Sun's place, or the star, to the graduated side of the brazen meridian, which is numbered from the equinoctial towards the poles; and the degree of the meridian, over the Sun's place, or the star, will be the declination; and the number of degrees on the equinoctial, between the meridian and the first point of Aries, will be the right ascension.

EXAMPLES.

1. Find the Sun's declination, and right ascension, on the following days:

June 21st.
March 15th.
January 1st.
July 4th.
December 22d.
September 23d.
February 1st.
October 20th.
November 23d.

2. Find the declination and right ascension of—

Aldebaran.—*Answer.* Dec., 16° 6′ N.; Right Ascension, 66°.

Arcturus.
Algol.
Capella.
Bellatrix.
Sirius.
Pollux.
Canopus.
Vega.
Menkar.
Regulus.
Procyon.
Rastaben.

PROBLEM II.

To find the latitude and longitude of a Star.

RULE.—Screw the quadrant of altitude over the north or south pole of the ecliptic, according as the star is in north or south latitude; bring its graduated edge to the star: and the number of degrees, on the quadrant, from the ecliptic to the star, will be the latitude; and the number of degrees, on the ecliptic, from the first point of Aries, eastward to the quadrant, will be the longitude.

EXAMPLES.

1. Find the latitude and longitude of Aldebaran.—*Answer.* Latitude, 5½° S.; longitude, 67°.

2. Required, the latitude and longitude of—

Markab.
Rigel.
Arcturus.
Algorab.
Capella.
Sirius.
Scheat.
Mirach.
Menkar.
Regulus.
Procyon.
Fomalhaut.

PROBLEM III.

The declination and right ascension of a heavenly body being given, to find its place on the globe.

RULE.—Bring the given degree of right ascension to that side of the brazen meridian, which is numbered, from the equinoctial towards the poles; then under the given degree of declination, on the meridian, will be the star or place required.

EXAMPLES.

1. What star has 99½° of right ascension, and 16½° of south declination?—*Answer.* Sirius.

2. What stars have the following right ascensions and declinations?—

Right Ascension,	205°	Declination,	50¼°	N.
" "	150°	"	13°	N.
" "	341½°	"	30½°	S.

3. When Venus has 31½° of right ascension, and 12° of north declination, what is her place on the globe?

4. When Jupiter's right ascension is 212°, and its declination 20° south, what is its place on the globe?

5. When the right ascension of the moon is 350°, and its declination 12° south, what is its place on the globe?

PROBLEM IV.

The latitude and longitude of a heavenly body being given, to find its place on the globe.

RULE.—Elevate the north or south pole, according as the given declination is north or south, 66½°; bring the pole of the ecliptic to the meridian, and screw the quadrant of altitude over it; bring the graduated edge of the quadrant to the given degree of longitude, on the ecliptic; and, under the given degree of declination, on the quadrant, will be the star or place required.

EXAMPLES.

1. What star has 31° of north latitude, and 201° of longitude?—*Answer.* Arcturus.

2. What stars have the following latitudes and longitudes?—

Latitudes.	Longitudes.	Latitudes.	Longitudes.
12½° S.	41½°	5½° N.	67°
16° S.	86°	21° S.	331°
5½° S.	66½°	29° N.	299°

PROBLEM V.

The latitude of a place, day of the month, and hour of the day, being given, to place the globe so as to represent the appearance of the heavens, at that place and time.

RULE.—Elevate the pole for the latitude of the place; find the Sun's place in the ecliptic, bring it to the meridian, and set the index to twelve; if the time be before noon, turn the globe eastward; if afternoon, turn it westward, till the index points to the given hour; and the surface of the globe will then represent the appearance of the heavens for the given time and place.

EXAMPLES.

Represent the appearance of the heavens at New York, for—
October 12th, at 10 o'clock, P. M.
May 21st, at 9 o'clock, P. M.
December 22d, at 3 o'clock, A. M.

TABLE I.—STATISTICS OF THE SOLAR SYSTEM.

NAME.	Sign.	Times larger than the Earth.	Light and Heat. Earth being 1.	Hourly motion in Orbit.	Density, Earth being 1.	Inclination of Axis.	Inclination of Orbit to Ecliptic.	Eccentricity of Orbit in parts of semi-axis.	Apparent Diameter of Sun as seen from planet.	Synodical Revolution.	Time of Retrogradation.	Arcs of Retrogradation.	Weight of 1 lb. at planets.		Longitude of Perihelion.	Longitude of Ascending Node.
										days.	days.		lbs.	oz.		
Sun	☉	1,400,000			$\frac{1}{4}$	$82\frac{1}{2}$°							28			
Mercury .	☿	$\frac{1}{15}$	7	110,000	2		7°	.205	80′	116	22	12°		$9\frac{1}{2}$	$74\frac{1}{2}$°	46°
Venus . .	♀	$\frac{2}{10}$	2	80,000	$1\frac{1}{4}$	15°	$3\frac{1}{2}$°	.007	46′	584	42	16°		15	129°	75°
Earth . . .	⊕	1	1	68,000	1	$66\frac{1}{2}$°	0°	.017	32′				1		$99\frac{1}{2}$°	
Moon . . .	☾	$\frac{1}{49}$	1	2,300	$\frac{3}{5}$	$88\frac{1}{2}$°	$5\frac{1}{3}$°	.054	32′	$29\frac{1}{2}$						
Mars . . .	♂	$\frac{1}{7}$	$\frac{1}{2}$	55,000	$\frac{3}{4}$	$59\frac{1}{2}$°	2°	.093	21′	780	70	18°		8	$332\frac{1}{2}$°	48°
Vesta . . .	⚶	$\frac{1}{25000}$	$\frac{2}{50}$	45,000			7°	.097	13′	503	83	13°			$249\frac{1}{2}$°	$103\frac{1}{4}$°
Juno . . .	⚵	$\frac{1}{165}$	$\frac{7}{50}$	42,000			13°	.254	12′	474	99	12°			$53\frac{1}{2}$°	171°
Ceres . . .	⚳	$\frac{1}{120}$	$\frac{1}{8}$	41,000			$10\frac{1}{2}$°	.076	11′	466	99	12°			147°	$80\frac{2}{3}$°
Pallas . .	⚴	$\frac{1}{52}$	$\frac{1}{8}$	41,000			$34\frac{1}{2}$°	.246	11′	466	99	12°			121°	$172\frac{1}{2}$°
Jupiter . .	♃	1300	$\frac{1}{27}$	30,000	$\frac{1}{4}$	87°	$1\frac{1}{3}$°	.048	6′	399	120	9°	2	8	11°	$98\frac{1}{2}$°
Saturn . .	♄	1000	$\frac{1}{90}$	22,000	$\frac{1}{10}$	62°	$2\frac{1}{2}$°	.056	3′	378	135	6°	1	$5\frac{1}{2}$	89°	112°
Uranus . .	♅	85	$\frac{1}{368}$	15,000	$\frac{1}{5}$		$\frac{4}{5}$°	.047	$1\frac{2}{3}$′	370	151	4°		$12\frac{1}{2}$	$167\frac{1}{2}$°	73°
Neptune .	♆	60	$\frac{1}{900}$	11,000			$1\frac{3}{4}$°	.009	$\frac{5}{6}$′	367	180	1°			47°	130°

TABLE II.—THE SECONDARY PLANETS.

SATELLITES OF JUPITER.

Name.	Distance from Planet.	Inclination of Orbit to that of Jupiter.	Revolution.		Diameter.
	Miles.		Days.	Hours.	Miles.
I.	265,000	3° 18′	1	18½	2508
II.	421,000	3° 18′	3	15	2068
III.	671,000	3° 14′	7	4	3377
IV.	1,180,000	2° 36′	16	16½	2900

These bodies are supposed to revolve on axes in the same time as their revolution around the planet.

SATELLITES OF SATURN.

Name.	Distance from Planet.	Inclination of Orbit to that of Saturn.	Revolution.	
	Miles.		Days.	Hours.
1. Mimas	119,500	30°		22½
2. Enceladus	153,500	30°	1	9
3. Tethys	190,000	30°	1	21⅓
4. Dione	243,500	30°	2	18
5. Rhea	336,000	30°	4	12½
6. Titan	788,000	30°	15	23
7. Hyperion	1,000,000		21	4⅛
8. Japetus	2,297,000	42 45′	79	8

The eighth satellite is supposed to be about as large as Mars, and the remainder to be smaller, according to their respective distances. They are supposed to have a rotation on axes, in the same time as they revolve around the planet.

SATELLITES OF URANUS.

Name.	Distance from Planet.	Inclination of Orbit to that of Uranus.	Revolution.	
	Miles.		Days.	Hours.
1.	225,000	80°	5	21½
2.	291,000		8	17
3.	340,000		10	23
4.	390,000		13	11
5.	780,000		38	2
6.	1,556,000		107	17

Their motion is retrograde, and their orbits are nearly circles.

GLOSSARY OF ASTRONOMICAL TERMS,

WITH THEIR DERIVATIONS.

Altitude—Lat. Altitudo, *height*. The height of a heavenly body above the horizon.

Amplitude—Lat. Amplitudo, *largeness*. The distance of a heavenly body from the east or west points of the horizon.

Annular—Lat. Annulus, *a ring*. A term applied to an eclipse, in which the sun's disc looks like a ring.

Antipodes—Gr. Anti, *against*, and podes, *feet*. Those inhabitants of the earth, who live on exactly opposite sides of the earth, or feet to feet.

Antoeci—Gr. Anti, *against*, and oikos, *a house*. Those whose dwellings are on opposite sides of the equator, but under the same meridian.

Arctic—Gr. Arktos, *a bear*. The name of the circle in the vicinity of the Constellation of the Bear.

Antarctic—Gr. Anti, *against*, and arktos. The circle opposite the Arctic circle.

Aphelion—Gr. Apo, *from*, and helios, *the sun*. The point of the earth's orbit farthest from the sun.

Apogee—Gr. Apo and ge, *the earth*. The point of the moon's orbit farthest from the earth.

Apsis—Gr. Apsis, a *joining*. The aphelion or perihelion of a planet's orbit.

Apsides—Plural of apsis.

Astronomy—Gr. Astron, *a star*, and nemo, *to classify*. The science which classifies and describes the heavenly bodies.

Asteroids—Gr. Aster, *a star*, and eido, *to resemble*. Small planets between Mars and Jupiter, at first taken for stars.

Atmosphere—Gr. Atmos, *vapor*, and sphæra, *a sphere*. The body of air, vapor, &c., which encompasses the earth.

Azimuth—Arabic. The distance of a body from the north or south points of the horizon.

Astral—Gr. Aster, *a star*. Relating to the stars.

Axis, pl. Axes—Lat. Axis, *an axle*. The imaginary line on which the earth turns.

Almacantars—Arabic. Parallels of altitude.

Binary—Lat. Binus, *two by two*. A term applied to systems of double stars.

Culminate—Lat. Culmen, *the top*. To pass the meridian, because then it arrives at its greatest altitude.

Crepusculum—Lat. Twilight.

Cusps—Lat. Cuspis, *a point*. The points of the moon's disc, when horned.

Centripetal—Lat. Centrum, *a centre*, and peto, *to seek*. The force which urges a body towards the centre of motion.

Centrifugal—Lat. Centrum and fugio, *to flee from*. The force by which a body recedes from the centre of motion.

Comet—Lat. Coma, *hair*. A body surrounded by a nebulous appearance, resembling hair.

Conjunction—Lat. Con, *together*, and jungo, *to join*. The apparent meeting of a planet with the sun.

Constellation—Lat. Con, *together*, and stella, *a star*. A group of stars.

Cardinal—Lat. Cardo, *a hinge*. The term applied to the four principal points of the compass.

Concentric—Lat. Con, *together*, and centrum, *a centre*. Concentric circles are those drawn around the same centre.

Disc—Lat. Discus, *a quoit*. The circular face of a heavenly body.

Diameter—Gr. Dia, *through*, and metron, *a measure*. The line which measures across a circle.

Digit—Lat. Digitus, *a finger*. One of the twelve equal divisions of the diameter of the disc.

Eclipse—Gr. Ekleipsis, *a fainting away.* The concealment of one heavenly body by the interposition of another.

Ecliptic—From Eclipse, a great circle in the heavens, so called because eclipses only take place when the moon is in its plane.

Eccentricity—Gr. Ec, *from*, and centron, *a centre.* Distance from the centre.

Elongation—Lat. Longus, *long.* The angular distance of a planet from the sun.

Equator—Lat. Æquo, *to divide equally.* The great circle which divides the earth into northern and southern hemispheres.

Equinoctial—Lat. Æquus, *equal*, and noctes, *nights.* A great circle in the heavens, so called, because when the sun is in it, every place on the earth has equal days and nights.

Focus—Lat. Focus, *a fire-place.* The point within the earth's orbit where the sun is situated. (Plural foci.)

Galaxy—Gr. Galaxias, *the milky-way.* Lat. Via Lactea.

Gibbous—Lat. Gibbus, *convex.* Term applied to the partial disc of the moon, or a planet, when more than half is visible.

Geocentric—Gr. ge, *the earth*, and centron, *a centre.* Seen from the earth as a centre.

Horizon—Gr. Horizo, *to bound.* The circle which bounds our vision.

Heliocentric—Gr. Helios, *the sun*, and centron, *a centre.* Seen from the sun as a centre.

Meridian—Lat. Meridies, *mid-day.* The circle at which the sun arrives when it is noon.

Nadir—Arabic, Nazeer, *opposite.* The point opposite the zenith.

Nebula—Lat. Nebula, *a cloud.* A cloudy appearance among the stars.

Nitrogen—Gr. Nitron, *nitre*, and gennao, *to produce.* One of the two component gases of air.

Nodes—Lat. Nodus, *a knot.* The points at which the orbit of a planet intersects the ecliptic, or plane of the earth's orbit.

Nucleus—Lat. Nucleus, *a kernel.* The bright and seemingly solid part of a comet.

Nutation—Lat. Nutation, *a nodding.* A vibratory motion of the earth's axis.

Orbit—Lat. Orbis, *a circle.* The path of a heavenly body.

Oxygen—Gr. Oxus, *acid*, and gennao, *to produce.* One of the component gases of the atmosphere.

Occultation—Lat. Occultatio, *a hiding.* The concealment of a heavenly body by the moon.

Octant—Lat. Octo, *eight.* The eighth part of a circle.

Parallax—Gr. Parallaxis, *change.* The difference in the apparent position of a heavenly body, from a change of place in the spectator.

Perihelion—Gr. Peri, *near*, and helios, *the sun.* The point of a planet's orbit nearest the sun.

Perigee—Gr. Peri, *near*, and ge, *the earth.* The point of the moon's orbit nearest the earth.

Perioeci—Gr. Peri, *around*, and oikeo, *to dwell.* Those who dwell under the same parallel, but in opposite meridians.

Penumbra—Lat. Pene, *almost*, and umbra, *a shadow.* An imperfect shadow.

Phase—Gr. Phasis, *an appearance.* The portion of a body's disc visible.

Planet—Gr. Planetes, *a wanderer.* An opaque body attending the sun, so called because, unlike the fixed stars, planets change their apparent relative positions.

Quadrature—Lat. Quadra, *a square.* The position of a body when its angular distance from the sun is 90 degrees, or a right angle.

Quadrant—Lat. Quadrans, *the fourth part.* The fourth part of a circle.

Quartile—Lat. Quartus, *fourth.* The aspect of two planets 90 degrees from each other.

Retrograde—Lat. Retrogradus, *backwards*. The apparent backward motion of the planets.

Refraction—Lat. Refractus, *broken*. The deviation or breaking of the rays of light.

Radius—Lat. Radius, *a ray*. Plural, radii. Lines drawn from the centre of a circle to every part of the circumference, as rays proceed from the sun.

Satellite—Lat. Satelles, *a guard*. An attendant body of a primary planet.

Sidereal—Lat. Sidus, *a star*. Relating to the stars.

Solar—Lat. Sol, *the sun*. Relating to the sun.

Solstice—Lat. Sol, *the sun*, and sto, *to stand*. The point of the ecliptic, at which the sun stands, with respect to declination.

Sextant—Lat. Sextus, *sixth*. The sixth part of a circle.

Stellar—Lat. Stella, *a star*. Relating to the stars.

Sextile—Lat. Sextus, *sixth*. The aspect of two planets 60 degrees from each other.

Secondary—Lat. Secundus, *second*. A great circle perpendicular to any other, or a term applied to the satellites.

Synodical—Gr. Syn, *together*, and odos, *a pathway*. The Synodical revolution is the time between two conjunctions.

Syzygies—Gr. Syzygia, *conjunction*. The conjunction and opposition of the moon.

Telescope—Gr. Tele, *at a distance*, and scopeo, *to see*. An instrument for viewing objects at a distance.

Terminator—Lat. Terminus, *a boundary*. The line which divides the enlightened from the dark part of the moon.

Transit—Lat. Transitus, *a passage across*. The passage of a planet across the sun's disc.

Trine—Lat. Trinus, *three*. The aspect of two planets 120 degrees from each other.

Tropics—Gr. Trope, *return*. The small circles which limit the sun's declination, so that, when it reaches one, it returns to the other.

UMBRA—Lat. Umbra, *a shadow.* The conical shadow of the earth or moon.

VECTOR—Lat. Vector, *one who carries.* The radius-vector is a line drawn from the sun, to any point of the orbit of a planet, by which the planet appears to be carried around the sun.

VERTICAL—Lat. Vertex, *the top.* A term applied to the sun when directly overhead.

ZENITH—Arabic. The point overhead.

ZODIAC—Gr. Zodiakos, *of animals.* The belt which contains the twelve constellations lying on the ecliptic, represented by animals.

ZONE—Gr. Zone, *a girdle.* A division of the earth's surface.

QUESTIONS FOR REVIEW.

1. What is Astronomy?
2. Of what bodies does it treat?
3. Into what two classes may the heavenly bodies be divided?
4. What is a luminous body?
5. What is an opaque body?
6. What is the Solar System?
7. What is a planet?
8. How many kinds of planets are there?
9. What is a primary planet?
10. What is a secondary planet?
11. Name the primary planets.
12. Mention the diameter of each.
13. Mention the distance of each from the sun.
14. What is the time of the annual revolution of each?
15. What is the time of the diurnal rotation of each?
16. How are the satellites distributed?
17. What are Asteroids?
18. Mention their number and names.
19. Which are the inferior planets?
20. Which are the superior planets?
21. Why are they so called?
22. What is elongation?
23. What is inferior conjunction?
24. What is superior conjunction?
25. What is opposition?
26. What is quadrature?
27. What is the disc of a heavenly body?
28. What is a digit?
29. What is the orbit of a planet?

30. What is the shape of the planets' orbits?
31. Repeat Kepler's laws.
32. What is the radius-vector of a planet's orbit?
33. What is the eccentricity of a planet's orbit?
34. What is centripetal force?
35. What is centrifugal force?
36. What is the aphelion?
37. What is the perihelion?
38. What is the apsis line?
39. What is the apogee?
40. What is the perigee?
41. What are the mean and true places of a planet?
42. Where is the velocity of a planet the greatest?
43. Where is it the least?
44. What are the nodes?
45. What is the ascending node?
46. What is the descending node?
47. What is the axis of the earth?
48. Mention the principal great circles on the globe.
49. Define each.
50. What is latitude on the earth?
51. What is latitude in the heavens?
52. What is declination?
53. What is longitude on the earth?
54. What is longitude in the heavens?
55. What is right ascension?
56. Mention the principal small circles on the globe.
57. Define each.
58. What is the equinoctial colure?
59. What is the solstitial colure?
60. What are zones?
61. Tell the position and width of each.
62. What is the horizon?
63. What is the sensible horizon?
64. What is the rational horizon?
65. What are the poles of the horizon?
66. Define each.

67. What is the altitude of a heavenly body?
68. What is the azimuth?
69. What are the vertical circles?
70. What is the prime vertical?
71. What is amplitude?
72. What is polar distance?
73. When has a place a vertical sun?
74. Where must a place be situated, to have a vertical sun?
75. What is the circle of perpetual apparition?
76. What is the circle of perpetual occultation?
77. How many positions has the sphere?
78. Define each.
79. What are the Antipodes?—Antoeci?—Perioeci?
80. What are the equinoctial points?
81. What are the solstitial points?
82. What are the signs of each?
83. What is the zodiac?
84. Repeat the signs of the zodiac.
85. Tell when the sun enters each.
86. What causes day and night?
87. How is the change of the seasons produced?
88. When are the days and nights everywhere equal?
89. When is it longest day in the northern hemisphere?
90. When, in the southern hemisphere?
91. When have places, in the north frigid zone, constant day?
92. What is the sun supposed to be?
93. What is its diameter?
94. How many, and what, revolutions has it?
95. How was the rotation on its axis discovered?
96. What are the spots, on the sun, supposed to be?
97. What is the velocity of light?
98. What is the supposed nature of light?
99. What is the position of the sun's axis?
100. Which planet is nearest the sun?
101. In what respects is it remarkable?
102. Mention the greatest elongation of Mercury.
103. When is Venus called the morning star?

104. When, the evening star?
105. What seasons has Venus?
106. What are the transits of Mercury and Venus?
107. What does a transit prove?—
108. What is the shape of the earth?
109. State its equatorial and polar diameter.
110. What proofs have we that it is spherical?
111. When does it pass its aphelion?
112. When its perihelion?
113. State the proofs of its revolving on its axis.
114. What gives it the shape of an oblate spheroid?
115. What is its density?
116. Mention the density of the planets.
117. By what is the earth attended?
118. By what is it surrounded?
119. Of what does the atmosphere consist?
120. Of what is air composed?
121. What are clouds?—Wind?
122. How is wind produced?
123. What are the trade winds?
124. How are they caused?
125. What are land and sea breezes?
126. How is rain caused?—Snow?—Hail?
127. What are fogs and mists?
128. How are they caused?
129. What is dew?
130. Mention some of the uses of the atmosphere?
131. What is the moon?
132. Mention its diameter, and distance from the earth.
133. How many revolutions has it?
134. What is the time of each?
135. What is a synodical month?
136. Why is it longer than a complete revolution?
137. Does the moon rise at the same hour, always?
138. Why does it rise later?
139. What is harvest moon?
140. Explain its cause.

141. What are the phases of the moon?
142. When is it new moon?
143. When is it full moon?
144. When is it first quarter?—Last quarter?
145. What is the appearance of the moon in each?
146. When is the moon horned?—When gibbous?
147. Can we see the entire surface of the moon?
148. Which is the fourth planet from the sun?
149. In what respects is its figure remarkable?
150. What phases does it present?
151. Why is it never horned?
152. What is the magnitude of Jupiter, compared with the earth?
153. What seasons has it?
154. By what is Saturn encompassed?
155. State the dimensions and distances of the rings.
156. Which is the remotest planet known?
157. State the time and manner of its discovery.
158. How are the asteroids distinguished from the other planets?
159. What is their average distance from the sun?
160. What is the time of their annual revolution?
161. What apparent revolutions have the heavenly bodies?
162. How are they caused?
163. How many apparent motions have the planets?
164. When is a planet's motion said to be direct?
165. When, said to be retrograde?
166. When is a planet said to be stationary?
167. How are these appearances caused?
168. When is the motion of an inferior planet retrograde?
169. When is it direct?
170. When does it appear stationary?
171. Describe the apparent motions of a superior planet.
172. What is an eclipse?
173. Which are the principal eclipses?
174. What is a solar eclipse?
175. How is it caused?
176. What is a lunar eclipse, and how is it caused?
177. Of how many kinds are eclipses?

178. What is a total eclipse?
179. What is a partial eclipse?
180. What is an annular eclipse?
181. When does it happen?
182. What is the ecliptic limit?
183. What is the extent of the solar ecliptic limit?
184. What is the extent of the lunar ecliptic limit?
185. What is the penumbra?
186. What is the length of the earth's shadow?
187. What is its breadth, where it eclipses the moon?
188. What is the length of the moon's shadow?
189. What is its diameter, where it intersects the earth?
190. How many eclipses may happen in a year?
191. What is occultation?
192. What are tides?
193. How are they divided?
194. What is flood tide?—Ebb tide?
195. How often do they happen?
196. What is spring tide?—Neap tide?
197. When do they occur?
198. By what are tides occasioned?
199. Which has the greatest effect, the sun or moon?
200. Why does the moon produce the highest tides?
201. How is spring tide caused?
202. How is neap tide caused?
203. What are primitive tides?
204. What are derivative tides?
205. Where do the highest tides occur?
206. What is the average height for the whole globe?
207. Do the tides always rise at the same hour?
208. Why not?
209. Does the tide rise immediately the moon passes the meridian?
210. Why not?
211. How much behind the moon are the tides, in the ocean?
212. How much at New York?
213. Does the tide rise as high, during the night, as during the day?

214. What is parallax?
215. What is the apparent place of a heavenly body?
216. What is the true place of a heavenly body?
217. What is diurnal parallax?
218. What is horizontal parallax?
219. Where is diurnal parallax the greatest?
220. Where is it the least?
221. How does it affect the apparent place of a body?
222. What is annual parallax?
223. What bodies have annual parallax?
224. What is the parallax of the nearest fixed star?
225. What is refraction?
226. Where is it the greatest?
227. Where the least?
228. How great is it, when the body is in the horizon?
229. How does it affect the apparent place of a body?
230. How does it affect the sun, at its rising and setting?
231. What is twilight?
232. How is it caused?
233. How far below the horizon is the sun, when it commences and ends?
234. At what parts of the earth is it shortest?
235. At what parts, longest?
236. What is time?
237. How is it measured?
238. How many kinds of days are there?
239. What is a solar day?
240. What is a sidereal day?
241. Which is the longer, and by how much?
242. Why is it longer?
243. What is apparent time?
244. What is mean time?
245. What is the equation of time?
246. When is it the greatest?
247. When is it nothing?
248. Explain the causes of the equation of time.
249. What is the precession of the equinoxes?

250. What is the amount of precession annually?
251. In what time do the equinoxes complete a revolution?
252. Explain the cause of precession.
253. What is a tropical year?
254. What is a sidereal year?
255. Which is the longer?—Why?
256. What motion has the line of apsides?
257. When does it complete a revolution?
258. How much does the longitude of thè perihelion, increase annually?
259. What are comets?
260. Of what parts, does a comet consist?
261. Define each.
262. How do comets revolve?
263. What are they supposed to be?
264. What are the fixed stars?
265. What are they believed to be?
266. What is their supposed size?
267. What is the distance of the nearest?
268. What are variable stars?—How accounted for?
269. What are temporary stars?—How accounted for?
270. What are nebulous stars?—Multiple stars?
271. What are double stars, and binary systems?
272. How many have been discovered?
273. What is the galaxy or milky-way?
274. What is a cluster?
275. What are nebulæ?
276. How are they divided?
277. Define each.
278. Of what is the universe supposed to consist?
279. What is a constellation?
280. How many are there?
281. How are they divided?
282. Explain the position of each.
283. Do the signs and constellations of the zodiac correspond?
284. When did they occupy the same places?
285. How are the stars classified?

286. What are telescopic stars?
287. What does the terrestrial globe represent?
288. What does the celestial globe represent?
289. What is the brazen meridian?
290. How is it numbered?
291. What is the wooden horizon?
292. What does it represent?
293. What is the hour circle?
294. When are meridians called hour circles?
295. What is the quadrant of altitude?
296. For what is it used?
297. What is the mariner's compass?
298. Mention the cardinal points of the horizon.
299. What is the angle of position of two places?
300. What are rhumbs?
301. What is a rhumb line?

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